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The Longest Bridge in the World

Southern Pacific Company's Salt Lake Cut-Off

Our frontispiece illustration shows a train on the twenty-mile trestle over Salt Lake on the Southern Pacific cut-off, which is the longest bridge in the World. This trestle work was constructed over twenty years ago, and was originally 27.5 miles in length, but about 8 miles was replaced with a great fill, a portion of which is shown in another of the illustrations.

The Salt Lake "cut-off," as it is now known is one of the most notable rectifications of early pioneer construction. The original line between Lucin and Ogden, Utah, made a circuit of the lake along the foot-hills of mountains where grades of 49 to 89 feet to the mile and curvatures of 8 and 10 degrees were encountered. The total distance between the above mentioned towns by the old line around the northerly end of the lake was 147 miles. In locating the new line, it was decided to run down to the desert level, continue on a tangent to meet the shores of the Lake, and then build a trestle across to the end of Promontory Point and continue by trestle to Ogden. By this revision, 43.77 miles in distance was saved. 3,919 degrees of curvature was eliminated, and the total grade was reduced by 1,515 feet. The sharpest curve on the new line is one and one-half degrees as against 10 degrees on the old line. The heaviest grade now is 21 feet to the mile on the original line. The force for completing the trestle and the equipment was planned on such a scale as would enable the trestle to be built at a rapid rate, and the maximum amount built in one

Southern Pacific Railway Train on 20-Mile Trestle Across Great Salt Lake week of six working days, working by daylight only, was 1.007 miles put up during a little over five working days. The temporary trestle was built in water which varied in depth from a foot or two up to 27 feet. The permanent trestle was built in water which was from 30 to 34 feet deep at the time of construction. Subsequently, in building the embankment to take the place of the temporary trestle, which was 8.03 miles in length, the material was

Midlake Station on Great Salt Lake Cut-off—Southern Pacific Railway

excavated near the east shore of the Lake at Little Mountain, and at Promontory Point, upon which the new line was built for a distance of about 4½ miles. Material was also obtained from mountains about 16 miles west of the Lake. The railroad runs on embankment in Great Salt Lake between the east shore and Promontory Point, a distance of 8.03 miles and on trestle between Promontory Point and the west shore for 19.45 miles, making a total distance of 27.48 miles from shore to shore. It is an interesting fact that, because the embankment between the east shore and Promontory Point almost entirely cuts off a portion of the Lake to the north from the main lake, the water of the Bear River, emptying into this part of the Lake, freshened the salt water to such a degree that in the winter immediately after the construction, ice one foot thick formed over the entire area to the north of the railway embankment.

As will be seen from our illustrations, the long trestle from Promontory Point to the west shore is an exceedingly fine piece of work. A solid timber deck was laid over the piling, and on this was placed 14 inches of gravel. Upon this firm bank the track has been laid, and along each edge of the floor is a high stout fence. The trip across the Lake by rail is unique. As is well known, the Lake, which at the time of construction of the cut-off was 75 miles long by 31 miles wide, is one of the most remarkable bodies of water extent, and it is more salty than any but the Dead Sea in Palestine.

Apprentice Education Making Rapid Progress

An encyclopedia of information on the subject of apprenticeship in the United States is now available in the Bulletin on Apprentice Education which has just been issued by the Federal Board of Vocational Education.

New methods of apprentice training have been made necessary by the introduction of large scale production in industry, the Bulletin shows. During the last fifteen years, we have witnessed the development of the class room method of apprentice education to supplement job experience. Such education has arisen either in the form of vocational training in the public schools, or through corporation schools under the auspices of employers, or through classes controlled by the trade unions.

The most surprising progress has been made along the lines of part-time apprentice training classes organized by the public schools, according to the Bulletin. Such training dates from the passage of the Federal Vocational Education Act in 1917. At the close of the fiscal year 1921-22, a total of 265,494 pupils were enrolled in such continuation classes. The Bulletin believes that the public school is destined to fill a role of increasing importance in apprentice education, since it supplies a neutral training agency, acceptable to both capital and labor.

Sharp issue is taken with the belief of many educators that the part-time school is only a temporary make-shift to be displaced as soon as the age of compulsory full-time education can be raised to a desired point. The Bulletin questions the wisdom of full-time education for boys and girls over 14, whose minds are set on employment. For such youths, industrial experience will prove of greater educational value than unwilling atetndance at high schools, it is declared. At the same time, the part-time school holds these young workers within the influence of the public school system.

Too many educators hold the "Camel" theory of education, says the Bulletin. They assume that the child is an intellectual camel, who can take his education in a prolonged meal—an educational gorge—store it up in an intellectual hump, and live off the hump all the way across the journey of life. They assume that the school is able, by itself, to furnish a balanced ration. They over-

Fill Forming Easterly Portion of Great Salt Lake Cut-off

look entirely the educational value of work for youth, as well as for older people.

Part-time vocational education bridges the gap between the job and the school, and enables the child to gain the cultural benefits of both, during his formative years, declares the Bulletin. The increasing use of the public school for apprentice training by both employers and trade unions will be a mighty stimulus to the growth of part-time education, it asserts. At the same time, it will give a new practical value to the public school.

Copies of this Bulletin are obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Annual Report of the Chief Inspector of the Bureau of Locomotive Inspection

The twelfth annual report of the Bureau of Locomotive Inspection to the Interstate Commerce Commission has just been issued over the signature of A. G. Pack, the chief inspector.

According to this report the percentage of locomotives inspected that were found to be defective increased from 48 per cent during the preceding year to 65 per cent, and the total number of defects found and reported increased approximately 70 per cent over the preceding year. The deteriorated condition of motive power is sharply reflected in the increased number of accidents and casualties. A comparison of accidents and casualties during the year as compared with the preceding year, covering the entire locomotive and tender and all of their parts and appurtenances, shows an increase of 117 per cent in the number of accidents, 118 per cent in the number killed, and 120 per cent in the number injured.

Records examined covering locomotive failures on a large number of railroads indicate that the number of locomotive miles per locomotive failure decreased as much as from 50 to 70 per cent during the year as compared with the preceding year. Every locomotive failure caused by physical defects carries with it potential injury to persons, serious delay to traffic, and heavy property damage.

During the year there were 57 boiler explosions which resulted in the death of 41 persons and the serious injury of 88 others, an increase of 75 per cent in the number of such explosions, 86 per cent in the number of persons killed, and 93 per cent in the number injured, as compared with the preceding year. While most of these explosions were caused by the crown sheet having become overheated due to low water in the boiler, the number of such cases where contributory defects or causes were found increased approximately 135 per cent as compared with the preceding year. The contributory causes found clearly establish the necessity for proper inspection and repair of all parts and appliances of the locomotive and tender if accident, injury and delay to traffic are to be avoided.

In previous reports reference has been made to certain investigations that had been made upon the water-indicating appliances, which established beyond question that gauge cocks when applied directly into the boiler for registering the general water level creates an unsafe condition and adds to the peril of the operation, it was recommended that a suitable water column, the best appliance yet devised, should be applied, to which should be attached three gauge cocks and one water glass, with an additional water glass applied on the left side or boiler back head so that those operating the locomotive might have accurate knowledge of the water level of the boiler under all conditions of service, which is necessary if safe and economical locomotive operation is to obtain.

Water columns, as recommended, have been applied to practically all new locomotives constructed during the past three years and on a large number of locomotives previously in service on most all of the larger railway systems.

In discussing the matter of autogenous welding the inspector states that numerous accidents were investigated where welds made by the fusion of autogenous process were involved. The result of our investigations fully supports our position previously taken that this process has not reached a state of development where it can safely be depended upon in boiler construction and repair where the strain to which the structure is subjected is not carried by other construction which conforms to the requirements of the law and the rules and regulations issued in pursuance thereof, nor in firebox crown sheet seams where overheating and failure are liable to occur, or on any part of the locomotive or tender subject to shock or strain where, through failure, accident and injury might result.

Numerous accidents have occurred due to the failure of autogenously welded seams and cracks in the boiler back head. One fatal acident of this nature occurred during the year where an autogenously welded crack 21½ inches long in the boiler back head failed while the locomotive was hauling a passenger train at an estimated speed of 35 miles per hour, resulting in death to the engineer and the serious injury of the fireman. The scalding water and steam escaping through the rupture compelled the engineer to leave the cab without being able to close the throttle or apply the brakes in the usual way. The engineer and fireman climbed out of and around the left side of the cab to the running board and to the front end of the locomotive, where the angle cock was opened and the brakes applied.

Serious acidents of a similar nature and character have previously been investigated and reports made public. The seriousness of such accidents to a fast-moving train can scarcely be contemplated.

The autogenous welding process is practically in its infancy, and due to my desire to avoid hindering the progress or development of any process of such great value when properly and discreetly used I have hesitated to ask this commission to establish or approve rules or regulations restricting its use. However, unless it is confined by the carriers to parts and appliances where, through failure, accidents and injuries will not result, we will be compelled to adopt some more restrictive measures in the very near future.

There were a number of accidents caused by defective grate shaking apparatus, the major portion of which were caused by the shaker bar not having a proper fit on the fulcrum lever. Many carriers have no standard design for such parts whereby they may be made interchangeable. Since it is impossible to avoid the changing of shaker bars from one locomotive to another in common use, it is apparent that each carrier should adopt and maintain a standard whereby shaker bars are made interchangeable with a proper fit on the fulcrum levers on all locomotives operated by it.

There were also a number of accidents due to the failure of injector pipes and these showed an increase in comparison with the previous year. In the majority of these cases the accidents were due to the injector steam pipe pulling out of the brazing collar because of defective workmanship and to breakage caused by weak, light construction and defective material. In many instances the failure of injector steam pipes was contributed to by the injector not being properly fastened so as to relieve the steam pipe from the weight and vibration of the injector and its connections. If injector steam pipe connections are properly made and maintained and injectors securely braced, accidents of this nature should be entirely eliminated.

Then, there was an increase in the number of accidents due to main and side rod, valve gear and reversing gear failures, nearly all of which could have been prevented by means known to every well-qualified mechanical official and employe in charge of inspection and repairs, and they have been largely due to a disregard of the requirements of the law and of well-established practices.

The law places the responsibility for the general design, construction and maintenance of all locomotives and tenders upon the carriers owning or operating them. It appears, however, that many railroad officials and employes who are responsible for the general condition and repair of locomotives coming under their jurisdiction have evaded their responsibility and knowingly allowed locomotives to remain in service in a seriously defective condition until found by our inspectors and ordered removed from service for needed inspections and repairs.

Even the number of locomotives miles per locomotive failure decreased from 50 to 70 per cent during the year as compared with the preceding year.

Among the recommendations made for the improvement of the service, it is suggested that all locomotives not using oil for fuel have a mechanically operated fire door so constructed that it may be operated by pressure of the foot on a pedal or other suitable device located on the floor of the cab or tender at a proper distance from the fire door, so that it may be conveniently operated by the person firing the locomotive.

This recommendation is based on the results of many investigations of boiler failures of such character as to permit the steam and water contained in the boiler at the time of the accident to be discharged into the fire box, many times being directed toward the fire door.

The old swing-type door, which is largely used at present, is almost invariably blown open in case of such accidents and permits the discharging steam and boiling water, with the contents of the fire box, to be blown into the cab of the locomotive, most frequently scalding and burning the persons therein. Such accidents frequently occur while coal is being put into the fire box, and with the fire door necessarily open, and under such circumstances it is impossible for it to be closed.

The automatic fire door would remain closed, if closed, when the accidents occur. If open, it would automatically close the moment the operator's foot was removed from the operating device, thus preventing the direct discharge of the scalding water and fire into the cab of the locomotive with such serious results.

The automatic fire door is not a new and untried device, as there are thousands of them in service, and they are required by law in some States. The automatic fire door is also of great value in prevention of serious cracks and leaks in fire-box sheets by limiting the time the fire doors are open when placing coal on the fire, thus reducing the amount of cold air admitted, which causes loss of temperature and consequent expansion and contraction and the setting up of great strain.

Their use is also very valuable in the conservation of fuel, which is one of the principal costs of operation.

It is also urged that a power-reversing gear be applied to all locomotives and that air-operated power-reversing gear have a steam connection with valves conveniently located in the cab, so arranged that in case of air failure steam may be quickly used to operate the reversing gear.

It is also recommended that a power grate shaker be applied to all coal-binning locomotives on the ground that such an appliance would not only prove of value in the conservation of life and limb, but would be of great value in the conservation of fuel by enabling the fireman to keep the fire in proper condition at all times.

All locomotives should also be provided with a bell so arranged and maintained that it may be operated from the engineer's cab by hand and by power.

The reason for this recommendation has been thoroughly discussed on previous occasions, and its necessity seems so apparent that it hardly requires further comment. We believe, however, that this is an appliance which is vital to the safety of the employes and general public at highways and other public places traversed by the railroads. The operation of modern motive power demands the full attention of the enginemen, and it is frequently the case while passing over road crossings and through congested territories that the engineer and fireman are so occupied with their other important duties that it is impossible for them to ring a bell by hand in order to give warning of approaching danger.

Attention is directed to the small size of the doors at the front of cabs and it is suggested that they should be made of such a size as to make an exit possible. At present it is often necessary to climb over the roof of the cab or out through the side window when it is desired to go from the cab to the running board in front while the engine is in motion.

Where such an enlargement of the front door is impossible it would be well to have a stirrup or other step and a horizontal handhold, on each side, of approximately

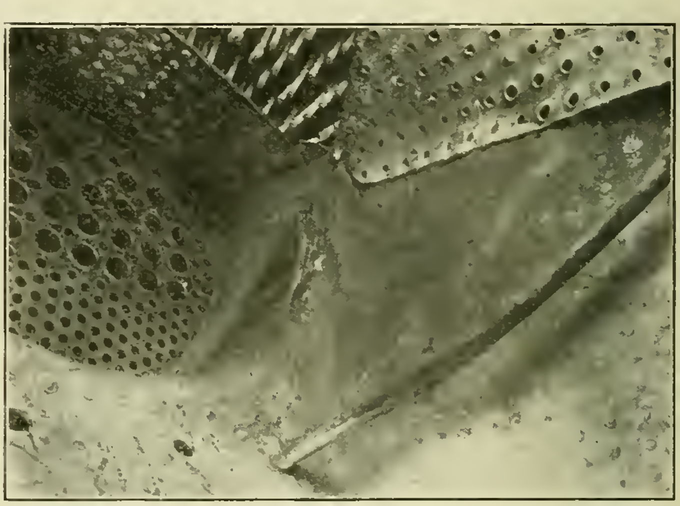

Fig. 1—Showing Crown Sheet Which Failed Due to Low Water

the full length of the cab, which will enable the enginemen to go from the cab to the running board in front of it.

The final recommendation is that all locomotives where there is a difference between the readings of the gauge cocks and water glass of 2 or more inches under any condition of service be equipped with a suitable water column, to which shall be attached three gauge cocks and one water glass, with not less than 6 inches, preferably 8 inches, clear reading, and one water glass with not less than 6 inches, preferably 8 inches, clear reading, on the left side or back head of the boiler.

Water glasses should be so located, constructed, and maintained that they will register the approximate general water level in the boiler under all conditions of service and show within 1 inch a corresponding level, and so maintained that the engineer and fireman may have under all conditions of service a clear view of the water in the glass from their respective and proper positions in the cab.

Gauge cocks should be located within easy reach of the engineer from his proper position in the cab while operating the locomotive, extension handles to be applied if necessary to accomplish this. All gauge cocks to be supplied with suitable nipples that will directly discharge into a properly constructed and located drain or dripper that will convey the discharged water to near the cab deck or floor, nipples to be not less than one-half inch nor more than 1 inch above the dripper or drain and kept in correct alignment.

Investigations have clearly established that gauge cocks when screwed directly into the boiler do not correctly register the proper water level over the crown sheet. It is very important that at least two appliances attached separately be employed for this purpose so as to form a double check and so as to have one appliance in case of failure of the other while on the road and away from points where repairs can be made.

Should any other appliance than the water column or water glass be invented which will safely and correctly indicated the water level in the boiler, due consideration can be given.

Following the main body of the report which is given in abstract above, there are a number of illustrations of failures that have occurred in locomotive appliances.

Fig. 1 shows a crown sheet which failed due to low water, the initial rupture evidently occurring in the autogenously welded seam, which failed approximately its entire length.

A B C

Fig. 2—Showing Opening in Boiler, Gauge Cock Opening Showing Scale and Same Opening with Scale Removed

The water-registering devices on this locomotive consisted of one water glass and three gauge cocks applied directly in the boiler back head. The water glass was broken en route, leaving only the gauge cocks for determining the general water level in the boiler.

After the investigation of this accident a test was made by one of the inspectors of the bureau, the superintendent of shop, the assistant superintendent of shop, and general boiler inspector on a locomotive of exactly the same class and type which showed that, with water at its lowest reading in the glass and safety valves blowing at capacity, the three gauge cocks registered full of water, or at least 6 inches higher than the water glass. Had a suitable water column such as has been recommended, and which is very generally being applied, been applied to this boiler, it is entirely likely that the accident might have been avoided.

In Fig. 2, *A* shows opening in the boiler practically closed with hard scale, from which bottom water-glass cock was removed. *B* shows the bottom of the water glass cock after it had been removed with the opening practically closed with hard scale. *C* shows the same water glass cock after the hole had been opened.

This locomotive was found in service by an inspector and it was observed that the movement of the water in the water glass was very slow and sluggish. He then issued special notice for repairs withholding it from service and found the condition as shown above. Records of this carrier showed that this boiler had been washed four days previous and the water glass spindles removed and cocks thoroughly cleaned, which records were evidently incorrect, as such a condition could not have developed in a period of four days in the territory where the locomotive was operated. Such conditions have been strong contributory or direct causes for some of the most disastrous explosions of which we have record. There is no plausible excuse or reason that can be acepted for allowing such a condition as this to develop.

Fig. 3 shows the arch tube and washout holes in a throat sheet and the accumulation of mud and scale which so restricted the flow of water through the tube that it became overheated and burst.

Such conditions cannot occur if boilers are washed out as often as the water conditions require, as called for by the rules. Arch tubes are subjected to high stresses and high temperatures under working conditions and, if accidents of this nature are to be avoided, it is essential that they be kept free from scale and sediment and a free circulation of water maintained through them.

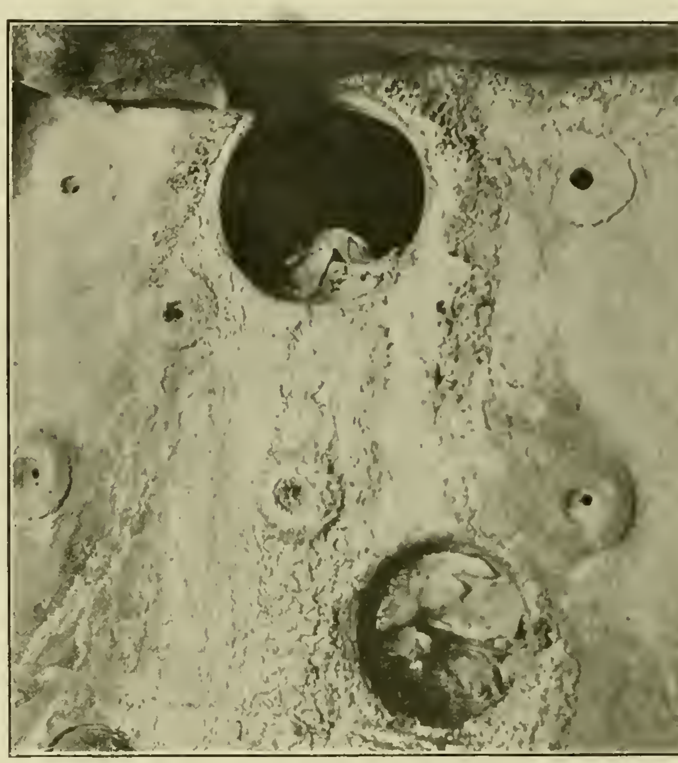

Fig. 3. Showing Arch Tube and Washout Holes with Accumulation of Mud and Scale

Fig. 4 shows a stud which blew out of the boiler back head causing the fireman to be seriously scalded. The threads were entirely worn and corroded away by constant and long leakage.

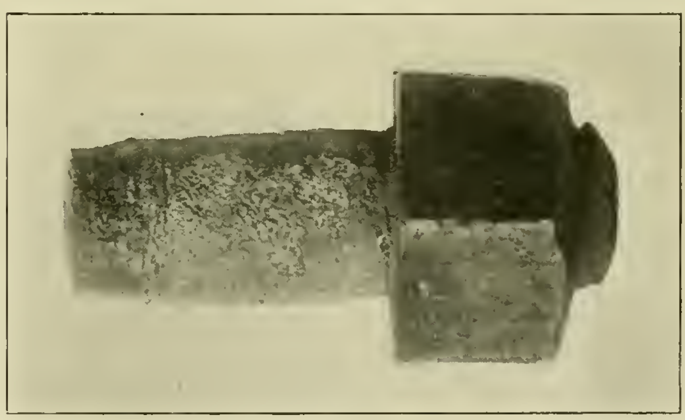

Fig. 4—A Stud That Blew Out of a Boiler Back Head

Such accidents as this usually result very seriously and can be prevented if proper attention is given to leaks around the threads of studs, which is always an indication of an unsafe condition. No locomotive should be permitted to remain in service with any stud leaking around its threads.

In Fig. 5 *A* there is shown a portion of an injector steam pipe as it appeared upon its arrival at a terminal. This steam pipe had been cracked and improperly repaired, as shown in detail at *B, C* and *D*, and it was leaking badly.

In attempting to make repairs a hole was burned in the pipe as shown at *B*. A piece of copper, as shown at *C*, was inserted in the hole and repairs attempted by autogenous welding, using steel welding material to repair a copper pipe. This piece of material is shown at *D*.

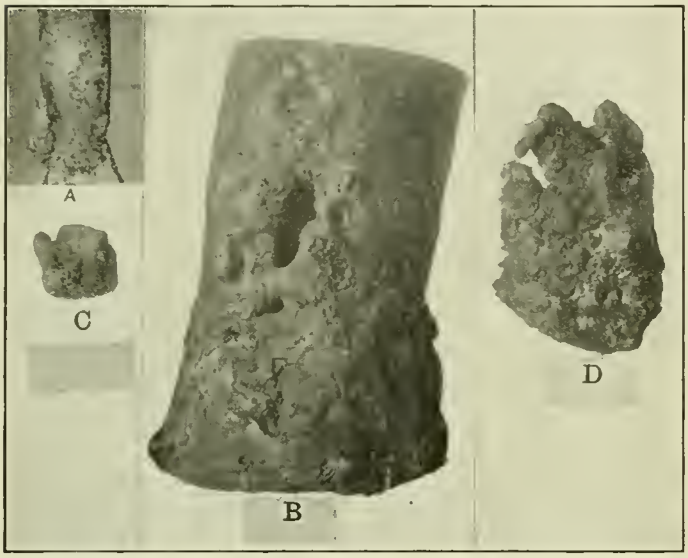

Fig. 5—Showing Injector Pipe that Was Not Properly Repaired

Such attempted repairs manifest a gross disregard for safety.

Since the law was enacted 254 accidents resulting in the death of three persons and the serious injury of 304 others have been due to injector steam pipe failures, all of which should have been avoided had proper construction, inspection, and repairs been made as required by the law.

Concerted Movement for Locomotive Fuel Economy

At a joint meeting held in Chicago on December 19, between the American Railway Association's Committee on Fuel Conservation and a committee of the International Railway Fuel Association, an important action was taken, looking to the consolidation of a large part of the test work and fuel research relating to fuel economy. The plan recommended would provide for the employment of a research director with the necessary staff for the consideration of problems relating to railway fuel operating economies.

While remarkable economies have already been effected there is still a vast amount of research work to be accomplished before the best results can be attained, and it is felt that none of the railways are in a position to complete this work individually. For this reason it is proposed that a co-operative plan be put into effect whereby a continuous use of one of the locomotive testing plants can be brought about.

This will not only afford authoritative information but will avoid a large duplication of effort.

The growing interest in fuel economy has focused increasing attention upon the relative fuel performance of the different lines so that it has bcome highly essential to apply a uniform ratio for equating coal and oil fuel in order to arrive at a comparative showing that is fair to all the railways concerned. The Interstate Commerce Commission does not now require the railways to use a uniform ratio in equating the quantities of fuel oil and coal burned.

At the December meeting steps were taken to present this matter before the Bureau of Statistics of the Interstate Commerce Commission with the recommendation that a ratio be adopted and made compulsory for all railways reporting quantities of fuel oil consumed in terms of pounds of coal.

It is intended to distribute a manual of fuel economy bearing briefly upon all phases of fuel conservation from a mechanical and purchasing department standpoint, the first part of which will soon be ready for publication.

A subsequent booklet dealing with the more mechanical phases of fuel economy will follow and eventually there will be four or five books comprising the manual, each of approximately the same length and scope. Consideration is now being given to utilizing one section of this manual of fuel economy for presenting an abstract of some of the most significant papers submitted by engineers, firemen, conductors, brakemen and switchmen in the recent contest for prizes awarded through the International Railway Fuel Association and various railways for the best papers on fuel conservation submitted by employees in these classes, more than two thousand papers having been submitted.

$1,075,897,940 Spent By Railroads Last Year

Capital expenditures made by the Class 1 railroads during the year 1923 for equipment and other facilities in order to meet increased demands for transportation were the greatest for any similar period in history, according to the Bureau of Railway Economics.

Capital expenditures actually made in 1923 for the purchase of equipment and other facilities totaled $1,075,-987,940, while unexpended authorizations made during the current year, but which will be carried over into 1924, totaled $300,806,519.

Of the total expenditures made in 1923, $690,857,266 was for equipment, while $385,040,674 was for roadway and structures, which includes additional track, heavier rail, additional ballast, shops and engine houses and other improvements.

Actual expenditures for locomotives in 1923 amounted to $212,225,204; for freight cars, $415,923,534, and passenger cars, $49,791,516. For other rolling stock and floating equipment the expenditures totaled $12,917,012.

Class 1 carriers also spent $116,215,710 for additional track and track material during the year, and $27,106,021 for heavier rail. Additional ballast cost $10,015,601, while expenditures for shops and engine houses, including machinery and tools, totaled $48,787,828. For other improvements not heretofore enumerated, $182,915,514 was expended.

Of the $300,806,519 unexpended authorizations which were carried over into 1924, $98,828,105 was for equipment. This latter amount includes a carry-over for locomotives of $20,665,383; for freight cars, $50,066,942, and for passenger cars, $14,793,182.

Unexpended authorizations for roadway and structures carried over into 1924 total $210,978,414, which includes $64,843,315 for additional track and track material; $19,-169,551 for shops and engine houses; $4,132,463 for heavier rail, and $4,109,155 for additional ballast. The carry-over for other improvements amounted to $118,-723,930.

Prize Winning Paper on Fuel Economy

W. L. Richards, Union Pacific Locomotive Engineer, Wins International Railway Fuel Association Contest.

More than two thousand papers were submitted in the contest for the prize of one hundred dollars offered by Mr. Eugene McAuliffe through the International Railway Fuel Association for the best paper on railway fuel conservation to be written by a locomotive engineer, fireman, conductor, brakeman or switchman. The unanimous selection of the judges was the paper submitted by W. L. Richards, a locomotive engineer on the Wyoming Division of the Union Pacific Railroad, which follows:

That the performance of any work whatsoever requires an expenditure of energy is an accepted fact; it is also a commonly accepted axiom that heat is the source of all energy, that is, that no work can be accomplished or power furnished without first providing heat. As an example, take a hydro-electric power plant, the first necessity in this case being a water fall, and at first thought, falling water seems to be far away from any thought of heat, but it only takes a very little consideration to bring us to the fact that the power in the water comes from its elevated position and the weight in it as it falls is what turns the water wheel or turbine and produces the energy to do work. Now then, if the elevation of a quantity of water above the common level is capable of producing power or energy, we have only to find out what elevated the water and we have the source of the energy in it. The common level of all water is the level of the oceans and the one and only way that it gets to the higher ground is by some of the surface water in the oceans being vaporized by the heat of the sun, carried as clouds by the winds to the higher levels and there deposited again as water or rain, and by this analysis we find that the source of the energy in the water fall was heat, the heat of the sun. In like manner, all sources of power or energy may be finally traced to be one of heat.

Railroads are engaged in the business of transportation, i. e., the carrying of goods or merchandise, articles of commerce, and persons from one place to another. To do this requires the provision of the necessary power or energy, hence the primary business of railroading is the business of furnishing energy to move things of weight; to furnish this energy requires heat, and, as fuel is the principal source of this heat, we are now ready to consider its economical use.

Division of the Subject

There are two ways in which the consumption of fuel may be lessened. The first is by lowering the amount of energy or power necessary to do a given piece of work; the second, by getting a greater amount of power from the fuel consumed. As both of the foregoing are controlled by those who are in charge, it would seem to be logical to say that three elements enter into the economical use of fuel, namely, operation, mechanical and personnel, and, therefore, it is from these three viewpoints that the subject will be considered.

Operation

In the operation of a railroad from a fuel economy standpoint, we are mainly concerned in the first way of saving, that is, by reducing the amount of work necessary to perform the service required. Under this head comes the reducing of road grades, the elimination of unnecessary car and engine mileage, the making up of trains so as to reduce the tractive effort to haul them, the rating of and providing of locomotives with trains which show the least fuel consumption per ton per mile hauled, the doing away with unnecessary terminal and road switching, the careful making up of time-table schedules so that the runs over the district concerned can be made with uniform speed and effort; the prompt handling of freight and passenger traffic so as to minimize delays and the avoidance of every train stop possible.

Perhaps much has been accomplished along the lines mentioned in the preceding paragraph, but there undoubtedly remains a great deal yet to be done before we can say we have reached satisfactory results. Take the matter of yard or termianl switching; I have in mind a case on a well managed railroad wherein a chief dispatcher had two trains made up at a certain terminal and they were run as made up to the end of that chief dispatcher's jurisdiction, but at the terminal where another chief dispatcher took charge of the movement of the traffic, these two trains were ordered re-made up in a manner that required 65 switches handling from 9 to 45 cars at each switch, took 2 hours and 20 minutes of a full yard crew's time and burned at least 2½ tons of coal. This is, perhaps, an exceptional case, but there are many cases of less magnitude happening on our best railroads every day and nearly all of which could be avoided had the trains been made up in the first instance under instructions that took into consideration the movement of all cars of which composed, clear through to destination or the end of that line of road, instructions which succeeding yard masters and chief dispatchers in the line of movement were bound to respect.

Practice of Making Paper Showing Often Causes Fuel Loss

There is also another phase of operation which is reflected in the fuel consumption of a railroad, and that is what is commonly known as making a "paper showing." It is practiced in nearly all departments and seems to be demanded by the system of accounting now in vogue. A train arrives at a terminal with ten cars of company coal in it, billed to a certain other terminal 300 miles farther on the line; these ten cars are taken off and ten other cars of company coal are put on in their place, the second ten being identically the same grade and kind of coal, loaded in the same line of cars and billed to the same terminal as the first ten, the change being made to make a paper showing of less delay to the coal in the yard concerned, that is, ten cars could be held, say, five days and a second ten could be held another five days, but if the first ten were held ten days, the showing would be questioned and, because of it fuel was wasted—yes, worse than wasted, because the time of a crew and the wear on the cars and locomotive went with it—for the railroad did not gain a single item in the change, the sum total of the delay being 100 days for one car in either case.

Instances in other departments might be cited. This "paper showing" often appears in keeping up the tonnage showing of a district, wherein one locomotive is sent out heavily loaded, followed, perhaps, by one running light because the power is needed at that end of the district and the "light" is not charged against the tonnage per train of the district, while tests show that to have run two small trains instead of the heavy train and the "light" would have resulted in the saving of considerable fuel and in either case the other expense for crews, etc., would have been the same. The amount of coal issued to locomotives is sometimes overcharged to make up for the shortage in weight of the coal between the mines and point of consumption to keep from showing up this loss, but the practice does not gain us one pound of additional fuel. It would be much better to make a true and exact charge, letting the shortage show and taking steps to correct it if large, and by so doing save ourselves a loss as well as to know that the records of actual fuel consumed were accurate.

Can't Accomplish Real Fuel Economy With Hand to Mouth Policy

If we except labor, fuel is the largest single item of expense railroads have to meet. While fuel saving campaigns have been inaugurated on most of our railroads and have resulted in the saving of some fuel, I am of the opinion that we have hardly scratched the surface compared to what might be accomplished if we go deep enough into the matter, and one of the first things to be done, and which can be done by methods of operation only, is to get entirely away from this habit of making a false showing on paper. Boards of directors and stockholders may have to be asked to look a little further into the future and give a little more leeway to the management in order to accomplish what appears to be necessary to the real saving of fuel. I refer to the practice of trying to show high net operating revenue at all seasons of the year.

On most of our roads the business is seasonal, and when the traffic is at the highest point mechanical forces are increased without stint in order to keep every available locomotive at work, but, at best, only the work absolutely necessary to keep the engine in service can be done, as it cannot be held idle long enough to be put in first-class mechanical condition, the result being that much fuel is wasted thereby; in fact, the matter of fuel economy is generally lost sight of entirely during these periods. Then just as soon as business slacks and gross revenues begin to fall, mechanical forces are reduced in an effort to keep the percentage of net revenue, with the inevitable result that the roads enter into another rush with the power in as poor condition as before.

At its best, this is a poor policy and is only "robbing Peter to pay Paul," for, when business began to fall off, had the full mechanical forces been kept at work until every locomotive had been put in the pink of condition, the money spent then would have been more than saved in the next campaign, because when engines are idle more work can be accomplished for the same expenditure, and many thousands of tons of fuel could be saved, for the reason that each machine would enter the rush in an efficient fuel-saving condition and could be maintained in that condition. The policy outlined would result in a further saving, as mechanical forces would be kept at a more constant level throughout the year, the filling of the shops with undesirable help during stress periods could be avoided and the cost of labor turnover be thereby reduced; this last, of course, is not strictly fuel economy, but would be a direct result of it.

As long as fuel economy is held to be a subject that must show immediate results, we shall not get very far in the matter. The cost of fuel is steadily rising and the time is fast approaching when capital expenditures will have to be made looking into the future for returns on the investment, and when this is done I am of the firm belief that the same railroad energy produced now will then be produced with 60 per cent of the fuel now consumed. A hand to mouth policy will never accomplish the real object.

Mechanical Factors

Although fuel is used in every department of a railroad, by far the largest percentage is that consumed by its locomotives, and a locomotive is a very wasteful machine at its best as far as fuel is concerned. During the government operation of the railroads, a bulletin issued by the director general gave the amount of heat usefully applied to drawbar pull by the average locomotive to be only 6 per cent of the total amount of heat in the coal consumed. This means that for every 100 pounds of coal burned only six pounds of it is really saved to do the work required, and from this fact it is easy to learn that we must devote our attention mainly to our engines if we are to save fuel in a mechanical way.

The bulletin spoken of in the preceding paragraph gives the largest amount of heat loss as that passing out of the stack—52 per cent—and it is to overcombing this high percentage that the mechanical department should devote the major portion of its efforts.

This means that every attention should be given to valves and cylinders; the cages of the former (the modern piston valve being under consideration) should be bored true and kept in that condition, as should also the cylinder walls, and both fitted carefully with rings of the proper size, with just the right amount of spring in them to make their movement steam tight, for if any of the live steam gets by it increases our percentage going out the stack, which cannot be permitted if we are to save coal. The setting of locomotive valves is a moot question, and therefore careful experiments should be made by each road to determine the setting that is most economical for its requirements, and when once the standard is determined, the valves should be "run over" as often as may be necessary to maintain it. "Lame" engines are to be avoided as fuel wasters.

The next great loss is that of unburned gases passing out the stack, the percentage of loss being given at 14 per cent, and it is to this factor that attention should be given, after the exhaust has been reduced to a minimum. For every ton of coal burned in a locomotive, from ten to fourteen tons of air are required to be drawn into the firebox to furnish the oxygen necessary for combustion. This air, remaining only a few seconds, must be heated to a high temperature, its various gases combined with other gases liberated from the burning coal and the greatest possible amount of the heat thereby generated transferred to the water to form steam. We must have the required amount of air or oxygen to make the gases which burn with the greatest amount of heat, but given that amount, more causes waste, for we have to heat more than is necessary, and it is thrown out the stack again, a total loss. Things which cause more air to be drawn in than necessary, and therefore to be avoided, are steam and water leaks in the firebox, too straight a passage, causing failure of the air to properly mix with the gases of the coal; too limited a heating surface for the hot gases to come in contact with and also allowing these metal surfaces to become coated with scale or soot. A leading authority says that a metal surface coated with 1/16 in. of scale or soot will transmit 14 per cent less heat than a clear surface of the same material, and these figures will give us an idea of just how important it is that accumulations of this kind be avoided. Brick arches are a great aid in the mixing of gases in the firebox and should be maintained in good order and of proper size wherever possible.

Pays to Put Locomotives in Good Condition and Keep Them There

Economical locomotive practices are so well known that it should be unnecessary to go into full detail in a paper of this kind. The whole secret lies in putting the machine in good condition, according to the facts we know, and then maintaining it in that condition. The writer feels we must do this to accomplish real fuel economy, and that too little attention has been paid to locomotive upkeep in the past. The order must go out to let nothing interfere with keeping the motive power in prime, efficient condition, and it will prove to be a move of utmost economy in the long run, as the following will witness: On a certain district of a well-known road there was an engineer who knew his business operating what is known as a "regular engine," that is, he was the only man running this particular engine. The district foreman in charge of the engine was the engineer's son, and, in order to please his father, paid marked attention to the work that was done on the engine concerned, with the result that it was probably in a better condition than any other locomotive on that road. Then came an order placing that engine in the "pool"; every engineer on the district then ran the engine in his turn, and it received no more than the ordinary attention, but for a period of nearly two years thereafter it was known as the lightest fuel user on the district, which it undoubtedly was, and as a result of being put in fine condition at the outset, saved enough coal in the ensuing two years to pay many times over the initial extra cost of being put in that condition.

There is one item that must be touched upon, however, and that is the matter of sand for locomotive use, and while it is mentioned under the head of mechanical, perhaps should have been spoken of under operation. At any rate, it has much to do with fuel economy and should receive more attention. Many a powerful locomotive has been allowed to spin and slip along for hours almost helpless, wasting coal and water (it takes fuel to pump water) for the want of a little sand under the driving wheels. On our heavy power, sand boxes should be enlarged and the best type of sander for the economical and sure use of sand be made a part of the engine equipment. Sanding engines by hand is a fuel waste because it takes an additional amount of coal to make up the long delay, and, therefore, mechanical sanding devices should be maintained wherever sand has to be frequently taken on.

Railways too Conservative Toward New Devices—Should Cut Red Tape

On the whole, railroads have been a little too conservative in adopting new and improved devices in engine operation to accomplish a great deal in fuel saving. Locomotives show less improvement for the time since being adopted for general transportation use than any other machine in general use for the same length of time. This has probably been due to two causes: First, the cheapness and plentifulness of fuel, and, second, the difficulty inventors have encountered in getting new devices tried out. A more progressive policy should be now adopted and new inventions of promise be tried out carefully with a view of being put into use if practical or to developing and remedying the faults of the inventor's idea. I know of a case where a certain type of tank-valve was causing a fuel loss by reason of stopping up easily and interfering with the feed water supply. A new type of valve was given a thorough and exacting test lasting for seven months and proved its superiority over the old valve in every particular, but failed to be adopted on the road concerned because other roads serving the same territory were using the same old type and it was deemed best not to change for that reason. This is illustrative of the attitude that must be gotten away from. If any improvement is to come, some one must cut a little red tape and do some pioneering.

What has been said under the heads of operation and mechanical pertains for the most part to train and engine operation, and while these are the principal fuel users, there are other departments where fuel is used, and, consequently, where fuel may be saved by the application of the two principles outlined—the saving of energy by the elimination of needless work and the getting the most out of the fuel actually used. A light burned when not needed, a shaft running when not being used and heat turned on when more windows are opened than needed for ventilation are some of the many ways in which needless work is performed; an efficient boiler or steam plant, well maintained and fired by skilled men, is one way of getting the most out of fuel used. All departments should be watched by competent supervisors, all power waste eliminated and methods revised with a view of lessening the work performed wherever and whenever it can be done without loss of efficiency.

Personnel

Although, in looking into the question of fuel economy, consideration has been given first to the matter of operation and then to the mechanical features, it is not intended to convey the impression that they are of more importance than the human factor in this great problem. Given operating conditions that practically approach the ideal, given mechanical attention that is almost perfect; we shall still register a failure in accomplished results unless we have employees who are intelligent and who have attained that degree of skill and interest in their work that will cause them to take full advantage of every opportunity afforded to save fuel. In order that we may have a set of employees who will measure up to the required standard, it would seem that we must approach the subject in two ways, i.e., education and selection.

Education. As many of the men who will have to do with the saving of fuel are old employees already in the service, the method of selection cannot be applied to them, and the effort will, necessarily, have to be confined to education. The older employees are naturally conservative, that is, they do not change the habits of a lifetime easily, and, therefore, the effort to educate them, to induce them to drop the old, wasteful habits and to take up the newer, more economical ways, will have to be carefully considered lest it do more harm than good. The writer believes the subject should be handled by the use of gentle and constant persuasion rather than by disciplinary measure so far as the older employees are concerned. In the case of the new employee, such as firemen, brakemen, apprentices and all who enter the service where they may go to higher positions, the educational feature should be made compulsory by means of carefully graded progressive examinations relative not only to the particular line of work in which engaged, but also that which pertains to the saving of energy and fuel.

The story of coal, its origin and use, how its elements may be combined with those of the air to produce heat, how the different combinations produce the different gases with their varying degrees of heat when burned, reads like a romance if written in a simple manner, free from technical expressions, so that the ordinary reader may understand. If the problem of combustion could be written up by some authority in story form like Dr. Woods Hutchinson has written the story of many human ills for the Saturday Evening Post, I am sure that the tale would be full of lasting interest for all employees, young and old, and would eventually result in the saving of many tons of fuel annually. As one of the means of saving fuel, let us see if we cannot find such a writer and then carry his story to every man having to do with the burning of fuel.

A graduating class at a famous college once adopted as its motto the sentence, "There's more beyond," and it seems as though this saying is particularly adaptable to fuel saving. There is always more beyond the initial act in all we do on a railroad. Take a brakeman who has by his alertness discovered a brake not released and sliding the wheel; when he releases the brake he has not only avoided the chance of an accident by reason of a flat wheel, but he has caused a saving of fuel in three different ways—saved the extra coal that it took to pull the dragging wheel, saved the coal that it would have taken to furnish the power to turn the lathe that the flat wheel would have been required in and saved the coal that would have been necessary to smelt the ore to produce the steel that would have been cut from the flat wheel to make it round again. Without doubt there are thousands and thousands of instances like the above that are passed thoughtlessly by, but if we can make an educational effort that will bring to the mind of every employee that every act he does has a good or an evil effect on the amount of fuel consumed, we are bound to reap the benefit of that thinking on his part and the result will show favorably in the fuel saved account.

In the matter of compulsory fuel education among the younger employees, particularly engineers and firemen, they should be required to acquire a technical knowledge of combustion to a degree that will enable them to handle fuel in an economical way at all times and to know the reason for such handling. A large percentage of fuel waste is due to ignorance of the simplest laws of combustion, and if we can dispel this ignorance and impart knowledge in its stead, this knowledge will cause action on the part of employees that will be almost automatic and which will go far in the matter of fuel saving. Men do not habitually do the things that they know to be wrong, so if we can educate them to the right thing, they will, in the course of time, almost unconsciously do that which is proper and right, which in this case would be to handle fuel in a saving manner.

The educational features should be provided by the company and they should be carefully considered in order to make them as entertaining and as interesting as possible. Text books of easy grade, lectures, moving pictures, slides, etc., should be provided, as well as class instruction at regular and stated periods, and these means of instruction once provided, there should be no hesitation in requiring those concerned to make full attendance and to keep up the required grades at the periodical examinations.

Selection. If the railroads are to be retained in the hands of their private owners it will be because of their ability to demonstrate that they can be more economically managed and greater service rendered at less cost than if in the hands of the government, therefore it becomes more and more apparent that economy of operation is to be our first consideration and that we are not only charged with this responsibility by the stockholders, but by the public as well. If we are to meet this responsibility, the quality of the personnel manning the railroads must be improved. Provision has been made in a preceding paragraph for the improvement of those already in the service by educational means; a further improvement must be made by beginning at the source, that is, by selecting those that are to enter the service.

The writer believes that every railroad should have an employing department, the head of which should be an officer of general authority and who has been carefully, yes, very carefully selected because of his knowledge and judgment of men. This officer should have assistants—not necessarily persons employed exclusively for this purpose, for many times an officer in other lines would meet the requirements—located in every terminal, whose duty it would be to keep in close touch with the youth in his community and who would talk to and register the names of those likely to make desirable employees. Then when the time came to increase the number of employees during seasonal rushes of business, the new men to enter the service could be taken from the selected lists instead of making haphazard grabs from those happening to present themselves for employment. It is my observation that once a person of the less desirable class is allowed to begin work, such person is rarely eliminated and the entire personnel of the road suffers during his or her term of employment; therefore it is imperative that steps be taken to prevent the entrance of this class of labor.

For myself, I believe the time has come when some of the intelligent tests should be used in examining an applicant for service on our railroads. The use of the Binet test and its modified forms, as demonstrated by its use in the army, undoubtedly gives a very definite line on the native intellect of any individual and, given a high degree of mentality, education will easily develop a highly desirable worker; lacking in primary intelligence, instruction may develop those qualities which the applicant has, but cannot increase the amount of mentality originally possessed; intelligence is desirable in all classes of employment, but is particularly needed in train service employees, because they are often away from direct supervision and in time of stress must have that degree of thinking ability that will enable them to act on their own initiative, doing exactly the right thing and doing it quickly, if they are to be successful for themselves and for the road they represent.

While the idea of raising the standard of the personnel of a railroad is here presented with the thought in mind of saving fuel thereby, it should be apparent to all that the advantage gained will by no means be limited to that alone, but will permeate every line of activity of a transportation system. Supervision on our roads is being constantly increased; supervising officers come from the rank and file; so it naturally follows that if we have a higher standard of mentality in the ranks we will have a higher standard in the supervision. Along with the increases in the number of supervising officers come a corresponding chance for promotion for each employee, and the fact is beginning to be recognized that there are no lines of occupation that afford a greater chance for advancement for the individual than does the occupation of railroading, and, granting the fact, it is but another reason why the roads should avail themselves of the chance to secure the cream of the labor market by a selective process at the beginning.

The giving of prizes to those making the best records in fuel saving is not advocated. They are often awarded on a very narrow margin between worthy contestants, so narrow that chance or a slightly favorable advantage often determines the result and are thereby almost disheartening to those who failed to gain them, but whose effort was equally creditable. Small bonuses that can be earned by a majority of the employees concerned are, perhaps, more fair, but then the thought comes that if the conditions of award are such that the major portion can win, the minority, working under the same conditions and drawing equal compensation, should be required to earn the bonus, and thus it, too, becomes of doubtful value. If the need of a stimulus is felt, it had best be in the nature of profit-sharing in the savings effected; however, still better, the investment of any capital available for gifts in a manner that would make for a still larger saving of fuel.

Summary

Summarizing, then, and apologizing for the repetitions that may occur, the following is briefed and offered as a means of securing the utmost in fuel economy:

Operation

Reducing of grades where feasible. (Generally, this is being done as rapidly as possible for other reasons than that alone of fuel saving.)

Elimination of unnecessary car and engine mileage and terminal switching by the appointment of a committee on each railroad, headed by a general operating officer, to study these questions and put in effect all economies possible. The committees of connecting lines to meet to consider wasteful practices regarding deliveries of cars to each other.

Overhauling the system of comparative statements and accounts so as to present no incentive to make movements that consume fuel but do not give any actual earnings.

Do away with making certain overcharges to counterbalance shortages. Let the shortage show and make every effort to eliminate, frankly acknowledging that which cannot be overcome. Make every fuel charge true and exact so the records will mean something.

Careful make-up of train schedules, calling in representative engineers and conductors on the districts under consideration to give advice as to the proper distribution of time so the run may be made with the least effort.

Overhauling and rebuilding locomotives during the slack season.

Discontinuance of the practice of keeping a locomotive in service until a certain number of miles have been made regardless of excessive consumption of fuel due to wornout fireboxes, flues or machinery. It takes fuel to overcome leaks, and when boxes or rods become so worn that they pound themselves hot it takes more fuel to strike the blow that causes the heat.

Organization of fuel committees (or the maintenance of them where already organized), one for each terminal, composed of local officials and a member from each branch of the service, meetings to be held at stated intervals to receive fuel saving suggestions, act on them and see to the enforcement of those adopted; one or more delegates from each terminal committee, together with division officials to form the next higher or division committee to handle fuel matters that are beyond the jurisdiction of the terminal committees, the whole to be headed by a central fuel committee, composed of general officers, they to make findings in all cases that have failed of disposition in the lower committees and to have general jurisdiction over all.

Mechanical

Maintenance of locomotives in prime condition, paying particular attention to:

Cylinders, pistons and cylinder packing; valves, rings and cages, as to fit.

Keeping the valves "square."

Allowing no leaks either in firebox or front ends; front ends airtight.

Use of brick arch in firebox wherever possible.

See that tenders have sufficient coal carrying capacity without being loaded to a point where coal falls off to be wasted.

Keep decks in smooth, level condition, so fireman may easily get just the amount wanted on scoop.

Maintain stop board on right side of shoveling sheet to keep coal from spilling out gangway.

Water valves in injectors should have stems packed tight enough so they will stay where set. Feed water supply under perfect control makes for less fuel consumption, and, in this connection, one injector that has sufficient capacity to supply the boiler is more economical than where it is frequently necessary to use both; in the one case, the supply being steady and easy to fire, against the other requiring "slugging" to overcome uneven supply.

Draft appliances and grates should be of such design and adjustment as will best take care of the particular kind of fuel being used.

Boilers and flues kept free from scale; the latter to be kept free from soot also by frequent cleaning.

Where roundhouse facilities are short, additional house room should be provided as soon as possible. Enormous quantities of coal are uselessly consumed keeping engines "alive" and from freezing up during cold weather when they must be kept out of doors awaiting orders.

Close touch should be maintained between yardmasters, train dispatchers and roundhouse forces to avoid getting engines under steam a long time before they are needed.

Heating and power plants should be of a size that will give the required supply without being forced, skillfully fired and well maintained. The dense, black smoke rolling from most of the railroad plants indicates: (a) the plant is being forced, (b) is not being fired properly, or (c) is in poor condition; any or all of which should be remedied.

All kinds of steam leaks should be stopped. They are frequently found on passenger trains, locomotives, heating plants; in fact, wherever steam is used.

Lights of all kinds consume fuel. See that none are in use when not needed. Have plenty of ventilation for health's sake, but do not try to heat all outdoors during cold weather.

Selection and Education of Personnel

Education. Both old and new employees must be taught the rules of fuel conservation and be required to use them and obey their teachings.

Persistent carelessness in the use of fuel should be treated the same as any other infraction of the rules.

The best means of instruction should be provided by the company and pains taken to make it pleasant for the employees required to take it; that is, it should be made available at convenient hours, interfering with their earning time not at all, and with their recreation hours as little as may be consistent with the knowledge they must acquire.

Firemen and younger engineers and shop apprentices in the machine and boiler departments should be required to have some technical knowledge of the science of combustion. This is equally desirable on the part of the older employees in the lines mentioned, but making it a rigid requirement would probably cause a degree of hardship that should be avoided. The situation as to the old employees will soon work itself out satisfactorily, as they will gradually leave the service, and while in the service they will pick up and use much of the fuel knowledge of the younger men.

The education of the younger and new employees should not be left to chance. Their remaining in the service should be dependent on attaining certain markings as to grade, these markings to be determined by periodical progressive examinations.

Selection. Prospective employees should be selected in advance of their employment by means of an employing department, the methods of which are outlined in the body of this paper. This is not to be taken to mean that experienced men are not to be taken on as new employees. On the contrary, they are often valuable acquisitions to the service, but should be required to pass the same requirements as new men and should furnish satisfactory personal as well as railroad reference.

New employees should be taken on probation with the understanding that they are in no sense a permanent part of the organization unless they show an aptitude for the work. It is an injustice to the individual, as well as to the railroad, to allow them to continue long in the service as a square peg in a round hole. Lack of success as a railroad man does not necessarily denote lack of ability, and many a railroad failure has been highly successful in other lines. Consequently, both should be willing to sever connections for the good of each other.

The use of an intelligence test in employing new men is brought to your attention. It has its advocates, while others think it simply "bunk." The writer has faith in it.

Five-Hundred-Dollar Prize for a Safety Poster

J. C. Caviston, 30 Vesey Street, New York City, secretary of the safety section of the American Railway Association, announces that a prize of $500 will be paid to the person submitting, before February 11, the best poster for use in conducting the careful crossing campaign during the coming season; the sum of $200 will be given as a second prize and $100 as a third. In addition to this, $100 will be paid to the person submitting the best slogan for the campaign. The prizes will be decided by a special committee composed of persons of national prominence, the names of whom will be announced later. The chairman of this committee is H. A. Rowe (D. L. & W.), 90 West Street, New York City.

Cost of the I. C. C.

An appropriation of $4,262,284 for the Interstate Commerce Commission for the fiscal year ending June 30, 1925, is recommended by the Bureau of the Budget in the report transmitted to Congress by President Coolidge on December 10. This compares with $5,203,860 appropriated for the year ending June 30, 1924. Explaining the reduction, the Budget Bureau said: "The principal differences between the appropriation for 1924 and the budget estimate for 1925 are a decrease from $2,298,077 to $2,148,000 in the general appropriation involving a reduction in personnel from 843 to 798, amounting to $102,378, and a reduction of $47,699 in other expenses; a decrease from $554,687 to $537,524 in the appropriation for enforcing compliance with requirements of law relative to reports and accounts of common carriers; a decrease from $404,747 to $375,000 in the appropriation to enforce compliance with acts to promote safety, etc.; a decrease from $304,979 to $290,000 in the appropriation for boiler inspection, etc.; a decrease from $1,347,092 to $647,260 in the appropriation for valuation.

For the Railroad Labor Board the Bureau estimates $322,200 for 1925 as compared with $340,000 for 1924.

Theoretical Savings Effected by Using High Pressures and Super-Heated Steam

An Analysis of the Heat Required to Produce Various Steam Pressures and Temperatures of Superheat

The accompanying diagram has been worked out by Mr. John E. Muhlfeld, in order to show graphically the theoretical saving that can be effected by using high pressure and superheated steam instead of saturated steam at a lower pressure. The temperatures given in the diagram are in degrees Fahrenheit and the B. T. U. values are for the heat content in one pound of steam or water. They were calculated on the basis of the Marks and Davis steam tables.

The chart brings out the fact that, under ordinary conditions of operation, an economical use is not being made of the latent and sensible heat of evaporation which must be put into the boiler regardless of the amount of steam pressure. This will be appreciated if it is considered that, with no gauge pressure, or superheat and the temperature at the boiling point the total heat of the steam is 1150.4 B.T.U., whereas at 350 pounds gauge pressure and no superheat, the total heat of the steam is 1206.6 or an increase of but 56.2 B.T.U. to produce from boiling point, 350 pounds gauge pressure, which represents a B.T.U. increase of less than 5 per cent.

Again, at 200 pounds pressure, which is the general average used on modern steam locomotives, the total B.T.U. of saturated steam is 1199.2, and with 300 degrees Fahrenheit superheat, 1359.0. At 350 pounds pressure of the total B.T.U. of saturated steam is 1206.6, or an increase of only 7.4 B.T.U., as compared with the 200 pounds pressure. At 350 pounds pressure with 300 degrees Fahrenheit superheat, the B.T.U. value is 1375.8, or an increase of only 16.8 B.T.U. as compared with 200 pounds pressure and 300 degrees Fahrenheit temperature steam. This shows how little B.T.U. value, i.e., 7.4 B.T.U.'s in the saturated and 16.8 B.T.U.'s in the steam superheated 300° Fahrenheit, must be added to saturated steam at 200 pounds pressure in order to produce 350 pounds pressure or 75 per cent greater power, and which, up to the present time we have not done, due to our adherence to the design of locomotive boiler as originated by Stephenson one hundred years ago, and to the disregard, in steam locomotive practice (with the exception of the Mallet) of compounding, which is universally practiced in stationary and marine engine design where fuel economy is essential, and which is already being considered as a necessary refinement in internal combustion engine design.

Another comparison also brought out very vividly on the chart is the small difference in B.T.U. values between the very low and extremely high pressures when superheated steam is used. With steam at 50 pounds pressure and 300 degrees Fahrenheit superheat, the value is 1326.3 B.T.U., and at 350 pounds pressure with the same degree of superheat, the value is 1375.8 B.T.U., or a difference of only 49.5 B.T.U. or 3.73 per cent for the whole range of pressures that are given in the second table in combina-

Comparative Table on the Basis of 300° of Superheat

Steam at Gage Pressure	Superheat	Total Temperature	Total B.T.U.	Increase in Per Cent as Compared with Saturated steam at 50 lbs. Gage Pressure. Pressure	B.T.U.	Temperature
50	300°	597.7°	1326.3	0	12.55	100.8
100	300°	637.9°	1341.4	100	13.83	114.3
150	300°	665.9°	1351.4	200	14.68	123.7
200	300°	687.9°	1359.0	300	15.33	131.0
250	300°	706.1°	1365.3	400	15.86	137.2
300	300°	721.9°	1370.7	500	16.32	142.5
350	300°	735.8°	1375.8	600	16.75	147.1

Authority: Marks & Davis Tables.

tion with 300 degrees Fahrenheit superheat. A point to be taken into consideration in the use of these high pressures and superheat is the temperature range to which the material is to be exposed. As for the boiler, that is affected only by the temperature of the saturated steam, which will range from 212 degrees at zero gauge pressure to about 435.8 degrees, while the tubes and passages that are filled with superheated steam will be called upon to sustain a temperature of 735.8 degrees when 300 degrees of superheat are used.

By referring to the diagram published in RAILWAY AND LOCOMOTIVE ENGINEERING for October, 1923, showing the effect of heat on the tensile strength of steel, it will be seen that the strength rises with the temperature until the latter has reached about 500 degrees Fahr. This is above the temperature of the saturated steam which is only 435.8 degrees at 350 pounds pressure, but is below that of steam superheated 300 degrees at the same pressure, when the temperature is 735.8 degrees. In the case of the steels included in the diagram the tensile strength at 700 degrees is approximately the same as at temperature of 100 degrees, so that from this standpoint the use of these high pressures and temperatures are quite feasible.

Gage Pressure	Degrees of Superheat	Total Temperature	Characteristic	B. T. U. Value (100–1300)
0#	0°	212°	Heat of the liquid	180 B.T.U.
			Latent heat of Evaporation	970.4 B.T.U.
			Total heat of steam	1150.4 B.T.U.
50#	0°	297.7°	Heat of the liquid	267.1 B.T.U.
			Latent heat of evaporation	911.2 B.T.U.
			Total heat of steam	1178.4 B.T.U.
50#	100°	397.7°	" " " "	1229.4 B.T.U.
50#	200°	497.7°	" " " "	1278.3 B.T.U.
50#	300°	597.7°	" " " "	1326.3 B.T.U.
0#	0°	212°	Heat of the liquid	180 B.T.U.
			Latent heat of evaporation	970.4 B.T.U.
			Total heat of steam	1150.4 B.T.U.
100#	0°	337.9°	Heat of the liquid	308.8 B.T.U.
			Latent heat of evaporation	880 B.T.U.
			Total heat of steam	1188.8 B.T.U.
100#	100°	437.9°	" " " "	1243.0 B.T.U.
100#	200°	537.9°	" " " "	1292.9 B.T.U.
100#	300°	637.9°	" " " "	1341.4 B.T.U.
0#	0°	212°	Heat of the liquid	180 B.T.U.
			Latent heat of evaporation	970.4 B.T.U.
			Total heat of steam	1150.4 B.T.U.
150#	0°	365.9°	Heat of the liquid	338.1 B.T.U.
			Latent heat of evaporation	856.9 B.T.U.
			Total heat of steam	1195.0 B.T.U.
150#	100°	465.9°	" " " "	1252.0 B.T.U.
150#	200°	565.9°	" " " "	1302.5 B.T.U.
150#	300°	665.9°	" " " "	1351.4 B.T.U.
0#	0°	212°	Heat of the liquid	180 B.T.U.
			Latent heat of evaporation	970.4 B.T.U.
			Total heat of steam	1150.4 B.T.U.
200#	0°	387.9°	Heat of the liquid	361.3 B.T.U.
			Latent heat of evaporation	837.9 B.T.U.
			Total heat of steam	1199.2 B.T.U.
200#	100°	487.9°	" " " "	1258.9 B.T.U.
200#	200°	587.9°	" " " "	1309.7 B.T.U.
200#	300°	687.9°	" " " "	1359.0 B.T.U.
0#	0°	212°	Heat of the liquid	180 B.T.U.
			Latent heat of evaporation	970.4 B.T.U.
			Total heat of steam	1150.4 B.T.U.
250#	0°	406.1°	Heat of the liquid	380.6 B.T.U.
			Latent heat of evaporation	821.7 B.T.U.
			Total heat of steam	1202.3 B.T.U.
250#	100°	506.1°	" " " "	1264.6 B.T.U.
250#	200°	606.1°	" " " "	1315.6 B.T.U.
250#	300°	706.1°	" " " "	1365.3 B.T.U.
0#	0°	212°	Heat of the liquid	180 B.T.U.
			Latent heat of evaporation	970.4 B.T.U.
			Total heat of steam	1150.4 B.T.U.
300#	0°	421.9°	Heat of the liquid	397.3 B.T.U.
			Latent heat of evaporation	807.4 B.T.U.
			Total heat of steam	1204.7 B.T.U.
300#	100°	521.9°	" " " "	1269.6 B.T.U.
300#	200°	821.9°	" " " "	1320.8 B.T.U.
300#	300°	721.9°	" " " "	1370.7 B.T.U.
0#	0°	212°	Heat of the liquid	180 B.T.U.
			Latent heat of evaporation	970.4 B.T.U.
			Total heat of steam	1150.4 B.T.U.
350#	0°	435.8°	Heat of the liquid	412.5 B.T.U.
			Latent heat of evaporation	794.1 B.T.U.
			Total heat of steam	1206.6 B.T.U.
350#	100°	535.8°	" " " "	1274.0 B.T.U.
350#	200°	635.8°	" " " "	1325.5 B.T.U.
350#	300°	735.8°	" " " "	1375.8 B.T.U.

Comparison of the B. T. U. Values of the Characteristics of Saturated and Superheated Steam at Different Pressures and Temperatures

The "Still" System Internal Combustion Locomotive

We are indebted to our esteemed contemporary the *Locomotive Magazine, Railway Carriage and Wagon Review,* London, England, for the accompanying description and comments on a new development by the Still Engine Company of an internal combustion locomotive, which is known as the "Still" System and of which one is now under construction by one of the leading locomotive builders in Great Britain.

internal combustion motor is that the former gives fairly constant force irrespective of piston speed, while the latter can only work satisfactorily through a restricted range of velocity, and therefore requires some kind of variable transmission between the motor and the wheels. Of such devices hitherto suggested or in use there is a choice of the following systems:—(1) Direct mechanical, i.e., clutch and change-gear connection, as in road auto-

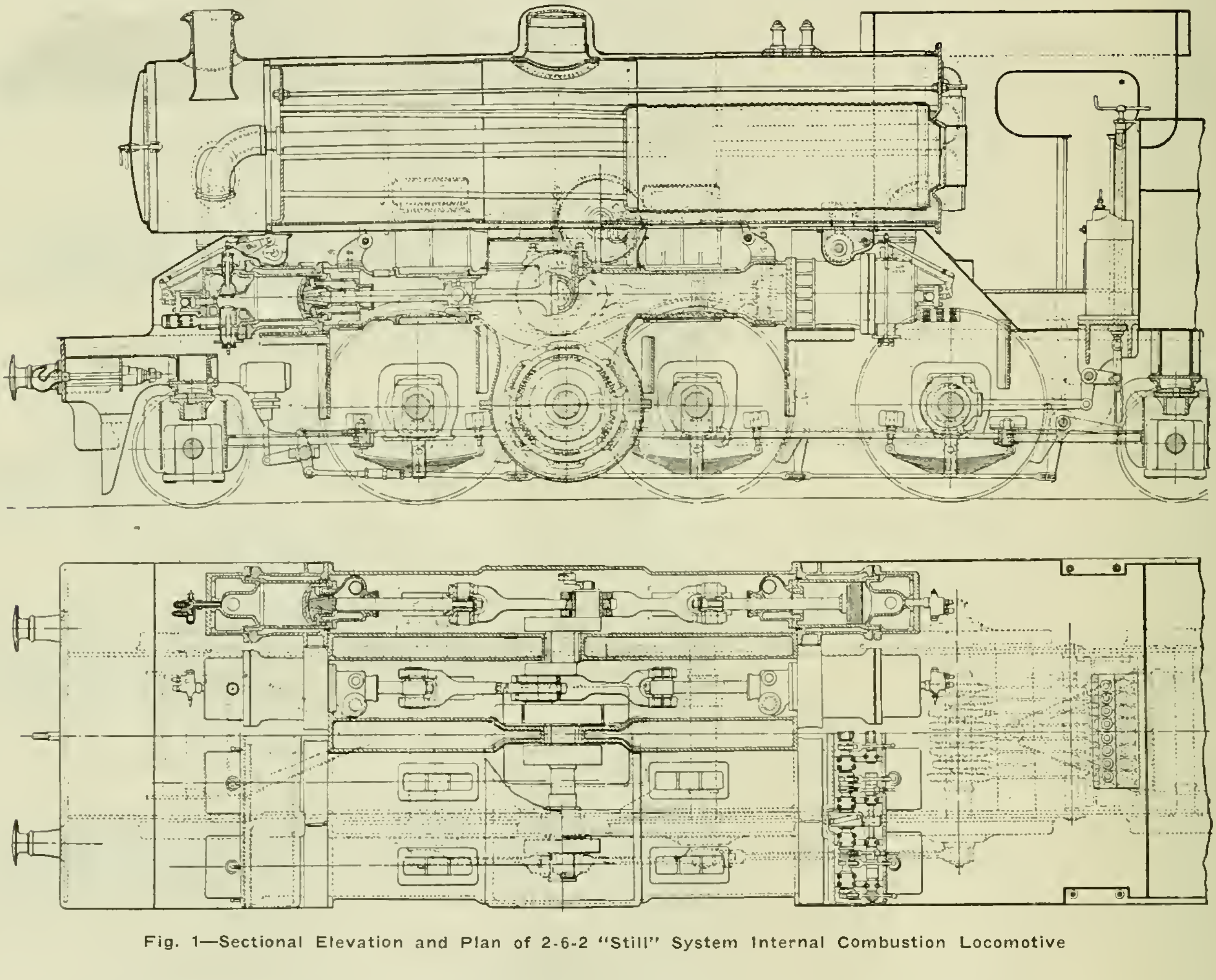

Fig. 1—Sectional Elevation and Plan of 2-6-2 "Still" System Internal Combustion Locomotive

From the aspect of thermal efficiency, the steam locomotive, when compared with other prime movers, particularly those in which the liberation of energy takes place within the working chamber, appears at serious economic disadvantage. The reciprocating, non-condensing railway engine, which is, and probably will long remain, the favorite type, notwithstanding the interesting turbine condensing engines now undergoing experimental investigation, yields at best an overall efficiency hardly exceeding 6 per cent, and this only when built in very costly fashion and working under favorable conditions.

Contrasted with the 35 per cent efficiency of the Diesel motor, such an output of energy seems most inadequate, but it must be remembered that the simplicity and adaptability of the conventional steam locomotive largely compensate for this defect; while the limitations of the internal combustion engine in its present form call for so many auxiliary organs that first cost and maintenance charges neutralize much of the benefit accruing from its inherent thermal superiority. Broadly considered, the outstanding difference between the steam engine and the

mobile practice. (2) Electrical transmission. (3) Hydraulic or pneumatic pressure. The first is ill adapted for dealing with high power; 200 H.P., is probably the limit. Whilst perhaps the most practicable in some respects (2) is very heavy and expensive; and (3) has the same objections coupled with others peculiar to methods of transmission by fluid pressure, either liquid or gaseous. Engineers do well therefore to proceed with caution in seeking substitutes for the familiar steam locomotive, and the lay public should beware of the somewhat premature obituary notices of this far from moribund machine, which irresponsible scribblers seem to enjoy inserting in the columns of the non-technical and "popular scientific" press.

We are far from wishing, however, in thus indicating a few of the difficulties of the steam versus internal combustion question, to suggest that important and serious advances are not to be anticipated; and although we foresee no total supersession of the steam locomotive during this generation, it is quite possible that developments of the internal combustion engine may come to offer precious solutions to some formidable problems for railway working—for instance, operation on lines where water supplies are inadequate or non-existent, and in services where stand-by losses entail heavy expenditure with steam engines of normal design.

Of these potential developments, none is more promising than the motor invented by Mr. Still. In its stationary and marine applications this engine gives an efficency of 40 per cent or more, this being the highest rendered by any fuel-burning prime-mover known; but its attractiveness for the locomotive engineer is chiefly that it provides a flexibility in working and a starting effort otherwise unobtainable without undue complication or the necessity for clutches, gear change, or the like devices for transmitting its power to the wheels. No doubt the principle of the Still engine is familiar to the majority of our readers, but it may be well to state it briefly in this place. Power is obtained by the combustion of some suitable hydrocarbon in a cylinder, as in a Diesel engine, but at a lower initial compression, and the residual heat, instead of being dissipated uselessly, is employed to generate steam, which, being stored under pressure, works expansively upon the side of the piston opposite to that subjected to the combustion forces. Additional steam, which serves for starting and raising the temperature of the cylinder, is generated separately in a boiler; and this steam may also act as a supplementary source of power when the engine is called upon to meet an overload. The heat of the exhaust gases is also utilized to raise steam, and is finally employed to warm the boiler feed water. Since the boiler is only needed to supply power at starting or (in the case of a locomotive when running at low speed, it is not required to be of any great capacity, and once the internal combustion motor has been started the fire may be reduced or extinguished; a proceeding best effected when consuming oil fuel in the furnace. In stationary and marine engines the exhaust steam is led to a condenser, but we understand that this is not regarded as desirable in a locomotive on account of the extra bulk and weight involved. Either the two-stroke or four-stroke cycles are applicable; each having certain arguments in its favor, the former being simpler in valve gearing, and the latter giving a somewhat higher efficiency. As the fuel is injected into the cylinder under pressure and ignited by the heat of compression, no carburetor or electrical ignition apparatus is installed; and owing to the preliminary heating of the cylinder certainty of ignition is assured, and the risk of developing excessive pressure in the cylinder, always present in ordinary engines, is avoided, so that the extra weight of material required to guard against the occasional danger of pre-ignition can be omitted in all Still engines.

As a result of very careful study of railway locomotive working by the Still Engine Company, an engine is now under construction by a leading firm of locomotive builders. For obvious reasons, it would be inopportune to enter into detail at present, but it is believed that this machine will follow the general lines indicated by the drawings attached to British Patent Specification No. 200,586, by Messrs. Margetson & Robinson.

It will be seen that this engine has six driving wheels, mounted in plate frames and held by boxes and springs of usual type. A pair of carrying wheels arranged in bissel trucks at either end gives the engine a 2-6-2 formation. Between the first and intermediate pairs of coupled wheels there is a jack-shaft, with external balanced cranks to which the coupling rods are articulated, and in the centre of this jack-shaft there is a gear wheel meshing with a corresponding wheel on the engine crank shaft. This engine crank shaft is above the jack-shaft and has four cranks upon it, the disposition of these cranks being shown by Fig. 2, which also indicates the order of firing of the eight cylinders. The cylinders are divided into two groups of four, located opposite to one another transversely, with each pair of opposed cylinders driving on a single crank through piston and connecting rods. The pistons act through piston rods transversing stuffing boxes and are attached to crossheads working in guides, the steam faces of the pistons being on the rod side and the internal combustion action taking place upon the other on a four-stroke cycle. Great care has been expended to secure balance of the reciprocating parts and very large surfaces are provided for all bearings and pins.

The steam generator consists of a cylindrical barrel extending right over the motive mechanism and comprises a firebox, also cylindrical in shape, and a number of tubes. Smokebox, boiler fittings, etc., are of the ordinary kind, a remark applying equally to the rest of the accessories.

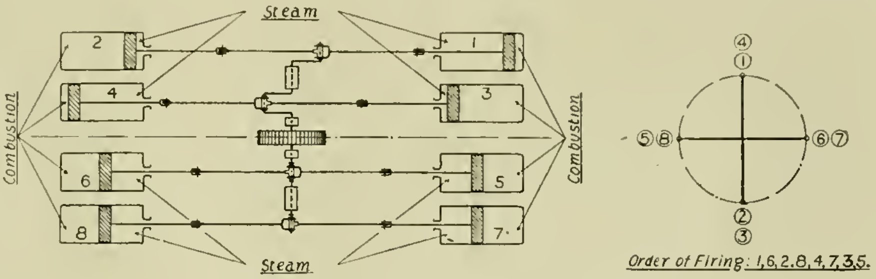

Fig. 2—Cylinder Arrangement Diagram

From the foregoing it is apparent that the Still locomotive can work under several modes of operation: (A) As in internal combustion engine alone; the residual heat being stored in the boiler; (B) as an internal combustion engine with additional power obtained from the regenerated steam—this being the normal method of working. (C) As in (B) but with auxiliary steam power from the boiler when the burner is alight. And (D), with steam alone; the last condition appertaining to starting and when moving below a speed of about five miles an hour, above which the internal combustion power comes into action.

The arrangement of cylinders, etc., adopted for the locomotive above described is but one of many possible and practicable forms, and we hope later to deal with another type of Still locomotive for which a different system of drive is being studied and provided with a motor working on the two-stroke cycle.

Hugo Stinnes After German Government Railways

Hugo Stinnes is trying to force the government to sell him the 30,000 miles of German nationally owned railways. The League of German Industries, in executive session recently, considered the project. Stinnes' chief associates are Peter Kloeckner, coal magnate; Albert Voegeler, iron king, and Herr Silverberg, head of the coal syndicate. Government experts estimate the value of the railways at $7,500,000,000. Stinnes, it is said, estimates them at much less. The government railways are facing financial breakdown. They must pay 190,000 officials and employees on lines in the Ruhr and Rhineland for which there is no revenue because they are in the possession of the French.

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The Competitors of the Railroad

For a number of years the motor truck has been increasing its radius of action and the efficiency of its operation, until it has become a real competitor to the railroad in many short hauls, less than carload lot cases.

It has, in some instances, become a large scale enterprise, with trucks running on a schedule that can be depended upon. Then there is the ordinary long-distance trucking for special loads. And the traffic has reached such a magnitude, that to a certain extent it has affected all roads and brought some of the smaller ones to the verge of bankruptcy.

In a way this competition is unfair, in that the motor truck does not pay its fair proportion of the cost of building and maintaining the highways in the destruction of which it is so potent a factor.

But the flexibility of its operation is such, and its convenience so great that it is useless to decry it and attempt to set it aside. Its convenience is especially marked in the conveyance of household goods which can be loaded at the door of the house to be left and unloaded at that of the one to be occupied.

It is in recognition of these facts and conditions that the announcement has been made that the Pennsylvania Railroad will handle short distance packages in less than carload lots between Philadelphia and Wilmington, Delaware, by motor truck.

This is an interesting development, but more startling yet is the statement that the aeroplane can not only compete with a railroad but can do so so effectually, as to prevent the construction of the latter.

During and since the war the chief source of the world's platinum supply has come from the mines near Quibdo on the upper reaches of the Atrato river in Colombia. These mines are located on the western slope of the Andes about forty miles in an air line from the Pacific coast, and about seventy-five miles from the nearest port. It was the intention, when the mines first assumed their worldwide importance to build a railroad to them. But it was found that the total output could be carried by aeroplane far more cheaply than by rail, if overhead be taken into consideration. Therefore, the construction of the railroad has been abandoned and the most modern method of transportation used in its stead.

The Chief Inspector's Report

The annual report of Mr. A. G. Pack, chief inspector for the Bureau of Locomotive Inspection is a most interesting document, but one that is rather distressing to read. The increase in the number of locomotive failures, and the citation of practices that bear a close resemblance to criminal carelessness are disheartening in the extreme.

Restrictive legislation usually follows upon the heel of abuses, and if the commission feel reluctantly obliged, at some future time, to restrict or prohibit the use of autogenous welding, for example, the railroads will have to put the whole responsibility for such restrictions upon those of their fellows who were responsible for the gross malpractice as have been illustrated in detail in Mr. Pack's most excellent report. That any man, in his senses, would attempt such a performance as that of trying to close a hole in an injector steam pipe by fastening a copper plug on a copper pipe with a steel welding wire, surpasses belief. In fact it is doubtful if it would have been believed, had not the statements been substantiated by the photographs. It is such practices as that that serves to give autogenous welding a bad name, and it behooves the demonstrators of the welding and welding supply companies, as well as all railroad officers in positions of responsibility, to instil by precept and example that such things should not and must not be done. There are some things that should not be attempted as yet, and, if a few reckless spirits persist in their recklessness, the result will be a check to the development of a very useful art, and, to use a hackneyed phrase, the innocent will have to suffer for the guilty.

But it is not in the matter of autogenous welding alone that Mr. Pack's report is disquieting. A few years ago he made one of the most valuable contributions to boiler lore that had ever been published when he showed that badly applied water gauges were quite unreliable as water level indicators. His contribution was not only a distinctive demonstration of common practice, but constructive in showing how a correct indication of water level could be obtained. One would have thought that, after such an explosion, no locomotive would have been permitted to go through a shop for general repairs without receiving the water column application that had been shown to be a reliable indicator and which was recommended. Yet here we find him reporting that, years afterwards, in consequence of a disastrous boiler failure, resulting from a defective application of the gauge cocks, it was necessary to make a demonstration before the superintendent of the shop, the assistant superintendent of the shop and the general boiler inspector, that on a locomotive, exactly like the one that had failed, the three gauge cocks registered the boiler as full of water, or at least 6 inches higher than the correctly indicating water glass. There is no excuse for such dilatoriness and men who will not accept the facts of a complete demonstration and act in accordance with them should be replaced by men who will.

Then there are the cases of carelessness: the permitting of steam and feed pipes to be entirely filled with sediment as illustrated in the December 1923 issue of RAILWAY & LOCOMOTIVE ENGINEERING; the allowing of studs with worn threads to remain in place, until they fail and kill or injure the members of the crew; for all of which there can be no excuse.

The great majority of railroad officers are earnest men who appreciate the responsibilities with which they are burdened, and act in accordance with their best judgment and on the best information available, and it is unfair to them that they should be "cabined, cribbed, confined," by men who are indifferent to their own welfare and the safety of the public.

There is no excuse for the deplorable state of affairs that the inspector's report sets forth, and it is to be hoped that when the time arrives for him to send out his next annual report a happier state of affairs will exist, and that without the application of the restrictions that are half threatened and which it has been feared, for some time, it might be necessary to impose.

The Cause of Derailments

When there exists an element of doubt on any matter of importance, the careful, fair-minded man seeks the truth from those of experience and integrity, but even with this precaution one is ofttimes considerably at sea from the fact that men of authority, experience and integrity do not agree particularly as to the cause of derailments, and the reason given for this difference of opinion by a recent writer on the subject may be expressed in the two following time honored expressions.

First:—That since the days of "Caesar" men have seen much of the things they *want* to *see*.

Second:—That we are all the product of our environment.

Either of the above will often serve to explain why if a motive-power officer is asked the cause of derailments he usually says defective track, while most maintenance of way and transportation men will say, defective equipment.

It might here be mentioned, however, that in many derailments or wrecks of any consequence, the actual condition of the track at the point of wreck, that may have caused the accident is completely changed, while there is always a mass of bent axles, broken wheels, bolts, oil boxes, etc., any one of which might cause a wreck, but all of which may have been in good physical condition prior to the accident, and their *damaged* or *defective* condition so forcibly emphasized by maintenance of way or transportation men, may and frequently is the *result* of the wreck, and not the *cause* of it.

The great trouble in getting the true facts is, that most men study one angle of this question only, and either through lack of ability to make a fair and impartial analysis from all angles or a predisposition to unload on the other fellow, usually approach the matter much on the same basis as many ambitious prosecuting attorneys, who are more interested in making a reputation based on the *number of convictions secured,* than on a proper administration of justice.

As an illustration, which is only one of numerous examples, a bad wreck occurred causing loss of two lives and much property. Those interested were soon on the ground, some of them building up an alibi rather than seeking facts.

In the tangled, twisted, broken mass of cars was in plain view a broken chilled wheel, also broken oil boxes and a badly bent axle. Photos were taken of this evidence and certain witnesses checked the parts carefully after which report was made to the effect, that without question the wreck was *caused* by a *broken wheel.*

Another investigator, however, who was seeking facts on which to base a just verdict rather than an alibi on which to escape responsibility, and who well knew the condition of the track was not good, went back over the track for some distance examining it carefully making notes and taking photos.

The track was not only out of surface and alignment, but was badly centre bound, leaving ends of ties unsupported particularly at rail joints, which were broken or alternated by half rail lengths on each rail line, this condition caused equipment passing over it to oscillate or roll and at such speeds as were necessary this rolling became so violent as to lift car wheels from the rail, and this was the actual cause of the wreck which was easily proven.

The actual wreck of the train was about 900 feet from the point of derailment of the car as shown by permanently clear marks on the ties, with a full clear flange on both wheels. After running about 800 feet on ties at the necessary rate of speed, the wheel was then broken by striking a guard rail, and the loss of life with all other damage followed. The broken piece of the wheel lay at this point, and the unquestioned "finger prints" it had left on the ties and guard rail proved it to be the *result* of the wreck and *not* the *cause* of it, and the over zealous prosecuting attorneys then found themselves in the position of having "framed their case," rather than having made an intelligent unbiased inquiry into a very important matter.

Then again there are cases where the permanent way or track is in good physical condition and the derailment is due entirely to a defect of the equipment that should have been detected and remedial measures applied, while in still other, and more frequent instances derailments are due to a combination of causes (a) defects in track (b) defects in equipment and (c) speed.

There are many able faithful railway men who can, and often do give a quick response to any question as to the cause of derailments, but in most cases if cross-examined their conclusions would be found to lack the necessary supporting data to stand the "acid test," and would quite frequently be subject to considerable modification. As an example; a certain trunk line noted for the high standard of its equipment and efficiency in operation had almost an epidemic of derailments of a new series of very fine cars built for a special service, the company's operating officers did not seem to be able to locate the trouble and apply a remedy with the result that a neutral expert was brought in, whose first move was to take stock as it were of the situation as viewed by those on the ground and at interest with the following result:

(a) The engineering and maintenance of way departments were almost unanimous in their endorsement of the high standard of physical condition of the track, and therefore they argued the trouble must be with the cars.

(b) The mechanical department took somewhat of a passive or non-committal attitude, due in this case largely to the fact that the cars in question were *not* of their design consequently their own personal or individual handicraft was not in jeopardy.

(c) There were numerous cure-alls proposed, some practical, many purely visionary, but none definitely prescribed for a specific ailment or disease so that in the last analysis the confusion of ideas as to the cause of the trouble and a practical remedy amounted to a rather genteel way of saying, "Well, it isn't my funeral and I am not much concerned as to how the other fellow solves his problems."—W. E. S.

Report of I. C. C. Discusses Rail Transportation in 1923

The Interstate Commerce Commission has just issued its annual report to Congress dealing with all phases of the work of the Commission and the railroads in the past year. While many of the details and statistics contained in the report are of interest, the most interesting parts deal with railroad performance, railroad earnings, the valuation of the railroads, and rates in the past year. Extracts from parts of the report dealing with these subjects are given below:

Railroad Performance in 1923

Three noteworthy facts have characterized the transportation history of the current year: :

1. The unprecedented volume of traffic handled.

2. The concurrent transformation of a car-shortage condition into one of car surplusage.

3. An exceptionally equitable distribution of available equipment over territory in which the large traffic movements originate.

During the first nine months of 1923 the carriers handled more freight traffic than during any previous corresponding period, the net ton-miles of revenue and nonrevenue freight being reported as 343,796,799,000. This represents an increase of 2.9 per cent over the corresponding period in 1920, which marked the previous record.

During the first 44 weeks of this year, January 1 to November 3, inclusive, 42,655,661 cars were reported loaded with revenue freight, an increase over the corresponding period in 1922 of 6,455,666 cars, in 1921 of 9,037,948, and in 1920 of 4,028,110. Not only was this unprecedented tonnage handled well, but the carriers reported a surplusage as of the week ended July 14 of 84,210 railroad-ownd freight cars in good repair and 11,035 cars of private ownership.

From June 22 to August 14 surplus cars increased from 58,671 to 78,404, and shortages decreased from 11,896 to 8,315. On five occasions between these dates more cars of revenue freight were loaded during a week than were ever before loaded in a similar period. * * * When it is recalled that at the end of the week of October 16, 1920, which marked the previous record loading, there was a shortage of 69,517 cars, and that on October 31, 1922, the shortage was reported at 179,239, the increase in transportation efficiency is apparent.

Factors Making Performance Possible

Some of the outstanding factors which have made possible this hitherto unequaled transportation performance are:

1. The condition of power and cars.

2. New locomotives and cars placed in service.

3. Increases in the mileage per car per day and loading of equipment.

For the month of September, 1923, the average mileage per freight car per day was 29.2, which is higher than the average for any month since these statistics were inaugurated six years ago. The average for August was 28.2 miles.

The extent to which shippers have utilized the capacity of cars is reflected in the average load per car. In September this was 27.4 tons, and in July and August was 28.5 tons. With the exception of the average loadings for August, 1918, 30.1 tons, and August, 1920, 29.8, the average for August this year is the greatest shown for any similar month since the records were inaugurated in 1917.

1923 Earnings

The marked business revival of 1923 has greatly augmented both the gross and net earnings of the carriers as compared with the earnings in the depressed years, 1921 and 1922 * * * In 1922, in spite of strike troubles, and the rate reductions effective in the middle of the year, the operating revenues increased to $5,617,252,656 and the net railway operating income to $776,665,960.

The year 1923 began with an inheritance of deferred maintenance resulting from the shopmen's strike. This has occasioned unusual expenditures for maintenance of equipment and has tended somewhat to reduce the net railway operating income, which for the first nine months of 1923 was $718,948,603.

For the calendar year the corresponding figure will probably be in excess of a billion dollars, but possibly not sufficiently to make the reported earnings equivalent to 5¾ per cent on the fair value of the property.

The improvement in the net earnings of the carriers noted above has by no means been equally distributed among the individual systems. The recovery from the depression of 1921 was more marked in the eastern and southern districts than in the western district in the first two-thirds of the year 1923.

Progress in Valuation

The outstanding development in the valuation work since the submission of our last report has been the progress in collating the data gathered by our field parties into the underlying accounting, engineering, and land reports upon which our tentative valuations are based.

Final reports were issued during the year in two important cases, Atlanta, Birmingham & Atlantic R. R. Company, and San Pedro, Los Angeles & Salt Lake R. R. Company.

In these reports we determined principles involved in the fixing of final values. In finding a single-sum value we identified it as a value for rate-making purposes. We declared that we are not bound by any formula in the valuation of railroads, but that we are to determine such value by consideration of all the evidential facts and the exercise of sound judgment in each case. Reproduction new and reproduction less depreciation costs were regarded as indicative but not determinative of value.

Original cost was regarded as a factor to be given consideration to the extent that it can be ascertained. We held that earning power is not the determining factor. In the case of the Atlanta, Birmingham & Atlantic we made deductions to cover improvident investment, and scaled down the value to that of a road adequate to perform, and that justified by the service rendered.

In the disposal of these cases we were not confronted to any considerable extent by the complications arising out of war and post-war period changes in price levels. These reports are being transmitted to the Congress.

Difficulties of Valuation

It was probably to be anticipated that, as the complicated work of valuing such an extensive facility as the railroad plant of the United States, having so intimate a connection with our national life, approached an advanced stage of completion, there would arise questions as to whether the work had been done in conformity with the desires or intent of the Congress.

Few public undertakings have presented more controversial questions than valuation of privately owned agencies of public service. Although the subject as it relates both to common carriers and public utilities has been one widely discussed and litigated for more than a third of a century, wide differences of opinion still prevail regarding many of the problems it presents.

These differences have not yet been set to rest either by commissions or by the courts. In the valuation of railroads we encounter all these complicated issues. It was not to be expected that in the most extensive valuation yet undertaken, and involving properties of great aggregate value, there would fail to develop the most searching public and legal inquiry into the administration and correctness of interpretation of a complicated act that is not entirely free from the ambiguities on which such claims have been based.

No General Rate Investigation

In our last report we referred to the general 10 per cent reduction in freight rates and charges which became effective July 1, 1922, as a result of our decision in Reduced Rates, 1922, 676. The effect during the calendar year 1923 of the rate reductions then made will be to lessen the total freight transportation charges paid by the shipping public by more than $500,000,000.

In our report in Reduced Rates, 1922, we referred to stabilization of rates as one of the important needs of commerce. With this in mind and having in mind also the desirability of giving the basis of rates established in July, 1922, a fair trial, and of avoiding the dislocation of business and commercial conditions often incident to investigations involving the possibility of important general changes in the rate level or in the relationship of rates, we have not made any further general investigation of rates during the past year. No general reductions over the country as a whole or throughout any of the major rate groups defined by us have been made by the carriers.

But Many Rate Revisions

But the year has continued to be one of transition and readjustment of rates, largely by reductions. As indicated by specific figures in the chapters covering the work of the several sections of the bureau, the number of freight rate changes made in 1923 has been even greater than the number made in 1922, which was, up to that time, the greaetst in the history of American railroads.

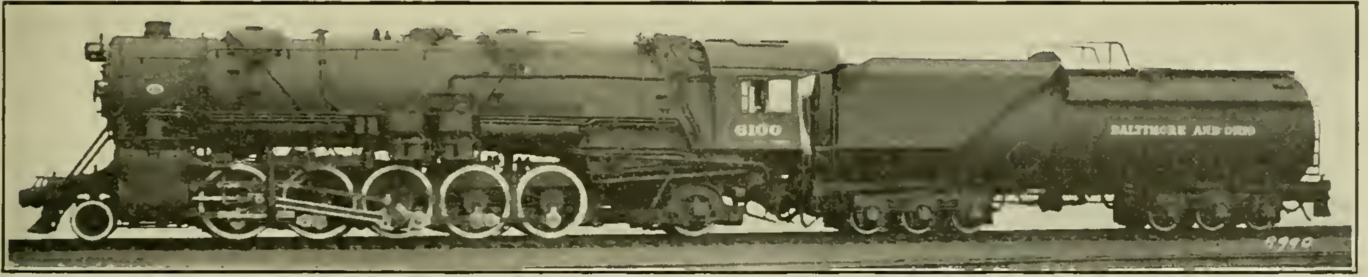
As in the preceding year, numerous rate controversies have been settled by negotiation with carriers and shippers without litigation. Where, upon protests of shippers, tariffs providing for changes in rates have been suspended by us, considerable success has attended our efforts to have the shippers and carriers adjust their differences, and in an increasing number of situations of this kind the protested schedules have been withdrawn by the carriers or have been permitted to become effective with such modifications as were agreed upon by shippers and carriers, thus avoiding the necessity of formal proceedings.

Commends Regional Advisory Boards

A new development now well under way is the organization by the Car Service Division of regional advisory boards, with various committees, for the purpose, among others, of anticipating car requirements and overcoming car-service and operating difficulties which can be worked out locally. Each board covers a convenient district and includes in its organization representatives of agriculture and important lines of industry. The committees of these boards report to the board as a whole, and the carriers co-operate with the boards. Both carriers and shippers are thus in position to understand more clearly each other's problems, and through this meeting on common ground can harmonize their differences. As a result better transportation service seems assured.

Heavy 2-10-2 Type Locomotives for the Baltimore and Ohio Railroad

The Baltimore and Ohio is now receiving from The Baldwin Locomotive Works, a consignment of 50 locomotives of the 2-10-2 type, which are notable chiefly because of their great size and hauling capacity. In these respects they represent practically the maximum yet attained in a non-articulated locomotive, designed to operate on tracks and bridges of the heaviest description. The tenders are, in their way, quite as remarkable as the locomotives.



Heavy 2-10-2 Type Locomotive of the Baltimore and Ohio Railroad, Built by Baldwin Locomotive Works

The last locomotives of the 2-10-2 type to be placed in service on the Baltimore and Ohio were built by The Baldwin Locomotive Works in 1914, and were designated as Class S. They had 30 x 32-inch cylinders and driving wheels 58-inches in diameter, and with a steam pressure of 200 pounds developed the high tractive force of 84,400 pounds. They have been used in both road and pushing service, and have proved especially satisfactory in the latter class of work; the majority now being employed on the Connellsville Division as helpers on the Sand Patch grade (1.98 per cent).

Except on the mountain divisions, where Mallet locomotives are employed, the standard heavy road engine of the Baltimore and Ohio is a Mikado type with 26 x 32-inch cylinders and 64-inch wheels. The new 2-10-2 type locomotives, designated as Class S-1, are designed to combine the hauling capacity of Class S with the higher speed capacity of the Mikado type; and with this end in view they also have driving-wheels 64 inches in diameter. These are probably the largest wheels ever used on a ten-coupled locomotive, and they fit the new design not only for heavy grade service, but also for work on divisions having moderate grades, where it is desired to haul an increased tonnage as compared with the Mikado type locomotives, while maintaining practically the same speed.

The Class S-1 locomotives are designed to traverse curves of 16 degrees, and have a maximum height of 15 ft. 5⅜ in., a maximum width of 10 ft. 11 in., and an overall length, engine and tender, of 100 ft. 8¼ in. The tires on the front and rear pairs of driving wheels are set 53 inches betwen their inside faces, and those on the second and fourth pairs 53¼ inches; while the middle (main) wheels have plain tires.

The boiler has a straight top, with a slope on the bottom of the barrel at the rear end, to give ample water space under the combustion chamber. The grate area is the same as that of the Class S locomotives, and the grate castings interchange in the two designs. The firebox has a combustion chamber 39 inches long, and contains a brick-arch supported on five water-tubes. A duplex stoker is installed.

The cylinder diameter is nominally 30 inches, but the cylinders are bored, when new, to a diameter of 29¾ inches; while the machinery is of sufficient strength for full steam pressure with the cylinders rebored to a diameter of 30½ inches. The cylinders and steam chests are fitted with gun-iron bushings, and this material is also used for the valve packing rings, and the piston bullrings and packing rings. The piston heads are of rolled steel, and the piston rods are of carbon vanadium steel. This latter material is also used for the main and side rods. The main rods have the Markel type of back end. The crank pins are of open hearth steel, the main pins being hollow-bored. Baker valve motion is used, and the gears are controlled by a screw reverse, similar to that applied to the last Pacific and Mikado type locomotives built for this road.

The frames are 6 inches wide, and are spaced 41 inches between centers transversely. An exceptionally strong double front rail construction similar to that used on the latest B. & O. Mikados, is applied to these locomotives. The frame rails are bolted to a strongly ribbed front deck casting, which is in turn bolted to the cylinder castings, forming a most substantial construction. The cast-steel cross-ties interchange, as far as possible, with those used in the Mikado type. The rear frame is of the Commonwealth cradle pattern and the rear truck is of the Delta type, so designed that the locomotives can subsequently be equipped with boosters should this appear desirable.

The tender is carried on two six-wheeled trucks of the Commonwealth type. The wheels are of forged steel and the journals measure 6 x 11 inches. The frame is a one-piece Commonwealth steel casting and the tank has a diameter of 9 ft. 6 in. and a length of 40 ft. 5 in. The tank capacity is 15,800 gallons, and the fuel space, which has a width of 10 ft. 6 in., carries 23 tons of coal. These are the largest tenders thus far completed by the builders, and their use will undoubtedly result in more economical operation, by making possible longer runs without stopping for supplies. In this way, not only is time saved, but the possibility of damage to couplers and draft gear is materially reduced.

Further particulars of these interesting locomotives are given in the table of dimensions:

2-10-2 Type Locomotive, Baltimore & Ohio R. R.,

Class S-1

Gauge		4 ft. 8½ in.
Cylinders		30 in. by 32 in.
Valves—Piston		14 in. diam.
Tractive force		84,260 lbs.
Service		Heavy freight
Boiler		
Type		Straight top
Diameter		90 in.
Working pressure		220 lb.
Fuel		Soft coal
Firebox		
Material		Steel
Staying		Radial
Length		132⅛ in.
Width		96 in.
Depth, front		91¾ in.
Depth, back		77⅞ in.
Tubes		
Diameter	5½ in.	2¼ in.
Number	53	232
Length	23 ft. 0 in.	23 ft. 0 in.
Heating Surface		
Firebox		262 sq. ft.
Combustion chamber		85 sq. ft.
Tubes		4881 sq ft.
Firebrick tubes		42 sq. ft.
Total		5270 sq. ft.
Superheater		1512 sq. ft.
Grate area		88 sq. ft.
Driving Wheels		
Diameter, outside		64 in.
Diameter, center		56 in.
Journals, main		13½ in. by 15 in.
Journals, others		11 in. by 13 in.
Engine Truck Wheels		
Diameter, front		33 in.
Journals		6 in. by 10 in.
Diameter, back		46 in.
Journals		9 in. by 14 in.
Wheel Base		
Driving		22 ft. 4 in.
Rigid		22 ft. 4 in.
Total engine		42 ft. 11 in.
Total engine and tender		89 ft. 10⅞ in.
Weight (working order)		
On driving wheels		347,230 lb.
On truck, front		31,570 lb.
On truck, back		57,710 lb.
Total engine		436,510 lb.
Total engine and tender		730,000 lb.
Tender		
Wheels, number		12
Wheels, diameter		33 in.
Journals		6 by 11 in.
Tank caapcity		15,800 U. S. gal.
Fuel capacity		23 tons

Equipped with superheater, stoker, and air brake on all driving and tender wheels, with two 8¼-in. cross-compound pumps.

Welding Locomotive Tires

Details of An Elaborate Investigation as to the Effect of Building Up Flanges

A thorough investigation was made some time ago, on a prominent railroad, in order to determine the effect on the strength of the material produced by local heating when building up worn tire flanges by either the gas or electric process of welding.

The investigation was made upon a number of locomotive tires that had failed, the reports of which showed that they had broken during the process of welding or soon afterward. An examination of the fractures showed that there was a structural change of the material in the region of the weld, indicating that strains had been set up by the welding process. Other failures were reported that seemed to have their origin in nicks produced by the cutting out of the retaining lip with a gas torch.

As the failures seemed to point towards faulty shop practices, the investigation was made in order to determine the strength and quality of the material in the broken tires. In addition to the tires broken in service, several worn tires were selected and welded in order to obtain data that would be available for comparison. They were also broken under a drop, and tension test pieces were also cut from the three points marked X, XX and Y in the outline of a section of a tire, and chemical analyses were made of these test specimens, so that a very complete idea of the actual condition of the several tires was obtained.

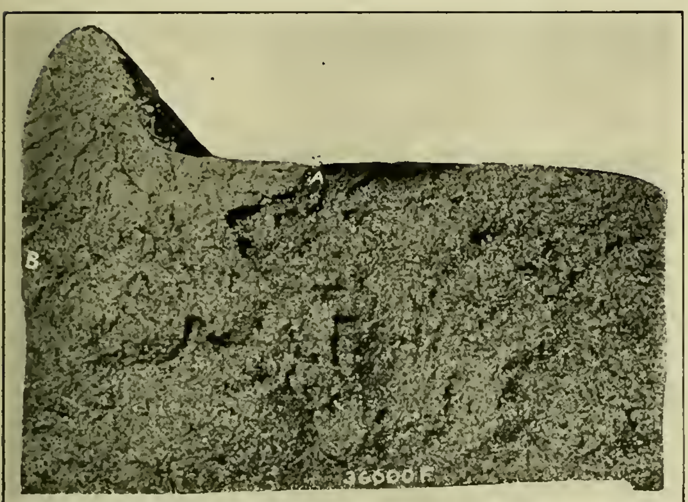


Fig. 1

The immediate visible effect of the autogenous welding is shown by the reproductions of the photographs of the fractures. This change was very evident in all of the fractures, the granular structure being very much finer in that portion which was subjected to the heating action of the torch.

The limit of space prevents the reproduction of the seventy-four photographs that were made in connection with the report. A few have, therefore, been selected that may be regarded as typical examples of the general results obtained.

Figure 1, shows the fracture in service of a tire which failed after the flange had been welded. Attention is called to the oxidized surface of the welding metal and the circular area of the changed grain structure produced by the heating of the gas flame, as indicated by the surface outside the curved line running from A to B.

Figure 2, represents a fracture produced under the drop test of a tire 1.97 in. thick, showing the structure as affected by gas welding, in the one marked 3 *B*, the structure that was not effected by any welding as in 3 D, and with an electric weld as in 3 F.

It will be noted that the difference in the effect on the structure of the material is very marked between the gas and the electric welding, as far as the penetration is concerned. This is probably due to the higher temperature of the electric arc which raises the surface up to a welding temperature with such great rapidity that there is not sufficient time for the same penetration as that which occurs with the gas flame.

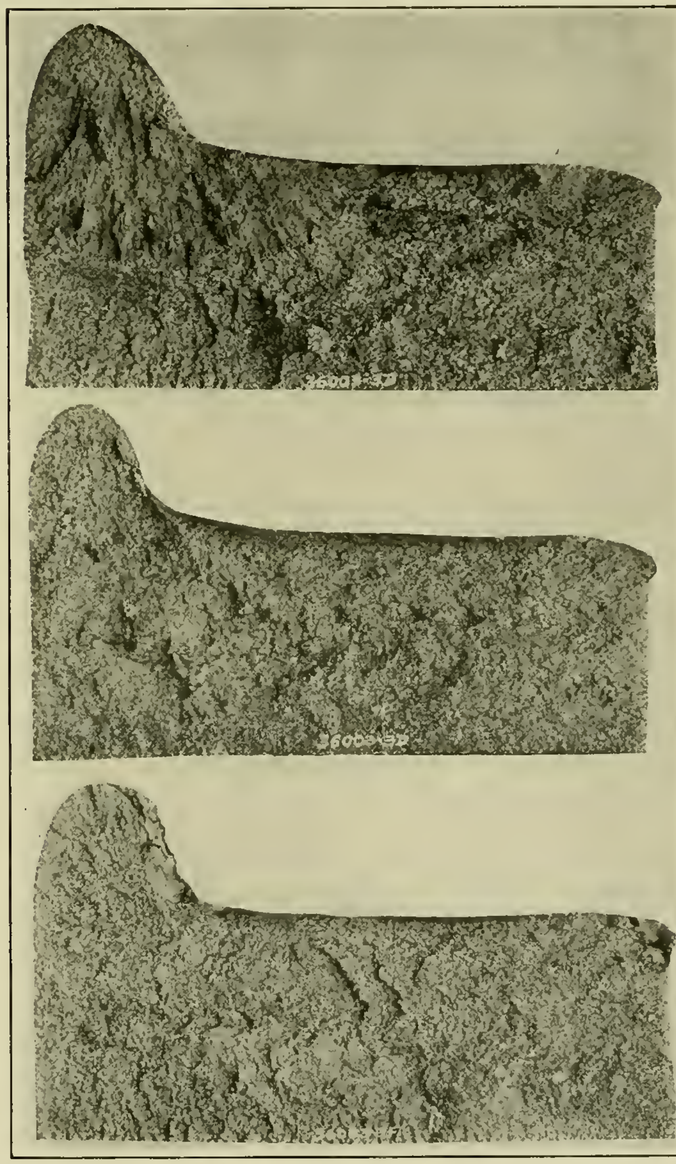


Fig. 2

Figure 3, is a reproduction of a light etching of a welded tire which failed showing the extent to which the structure is effected by the local heating of gas welding.

That these effects can be dissipated is shown by Fig. 4, which is a reproduction of a light etching of a tire that had been welded and then heated to a bright red and air cooled, by which the strains were apparently relieved.

Fig. 5 is a light etching showing the depth to which the heat effects may penetrate in welding and Fig. 6 shows a section of a tire with a narrow rim of hard metal produced by electric welding.

In the course of the investigation one hundred and forty drop tests were made on sections of tires varying in length of span. These spans were 15 in., 21 in. and 36 in., depending on the length of the specimen. The tread was usually placed at the bottom so as to be in tension, and the tests were made with a 1640-pound tup falling one foot at the start. This distance was gradually raised by one foot increments until failure resulted. In this way a series of values were obtained which showed the resistance of the tire to shock, and whether it was welded or not.

Fig. 3

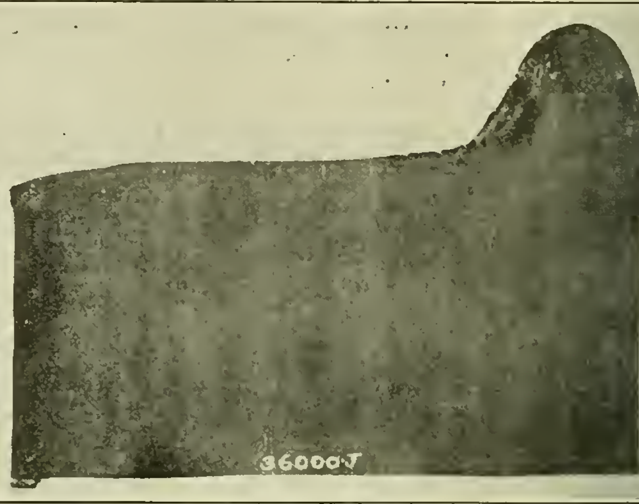


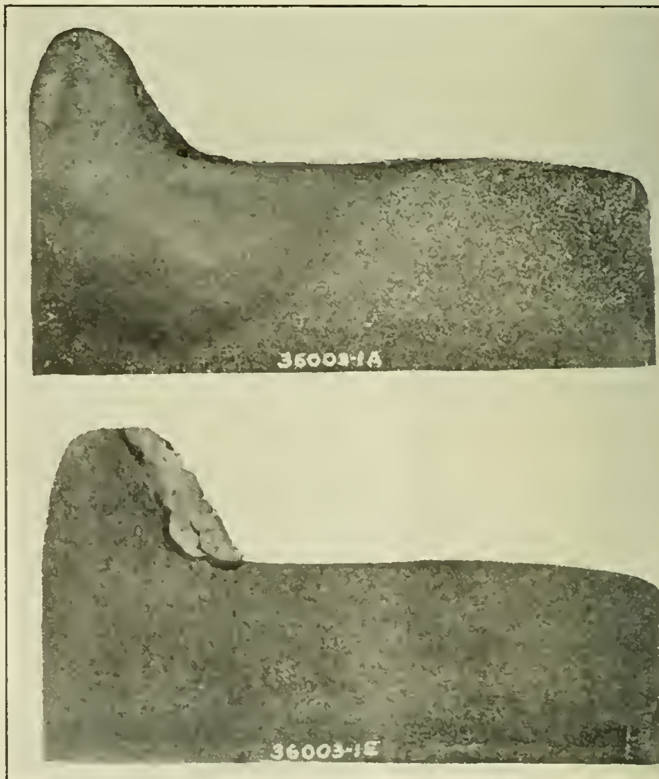
Fig. 4

The energy in foot pounds required to produce the breaks for each time were averaged and the results have been grouped and brought together in the following table in order to obtain a comparison of the effect of autogenous welding, that is the building up of the flange, with the unwelded tire.

Thickness in.	Carbon per cent.	Average energy to produce break, ft.-lb. Natural condition	Gas welded	Strength, gas weld to natural per cent.
2.80	0.56	......	6,150	52.2
2.54	0.61	11,000	....	....
2.90	0.58	12,600	....	....
2.30	0.68	3,520	2,710	77.0
3.40	0.63	......	5,990	....
3.46	0.62	26,600	....	22.5
1.85*	0.60	5,750	3,280	57.1
1.83*	0.61	4,100	3,280	80.0
1.97*	0.62	10,250	2,460	21.9
1.92	0.72	13,900	5,340	38.4
2.65	0.59	15,400	6,800	44.2
2.13	0.59	10,150	5,340	52.7
3.32	0.61	......	5,900	36.0
3.46	0.62	16,400	....	....
1.95	0.50	......	....	....
3.55	0.46	147,500	14,750	....
3.50	0.57	69,000	....	....
Average				48.2

The results of the drop tests show that the gas welding of the flange reduces the resistance of the tire to shock approximately 50 per cent while as will be seen later from the résumé of the tension tests, this same local heating increases the tensile strength of the metal effected by from 5 to 25 per cent. It will be seen, from the reproductions of the photographs already referred to that it is probable that the changed grain structure there shown, sets up internal stresses that reduce the resistance of the section to shock.

As for electric welding of the flanges, only three tire sections were welded for testing purposes. These were the three that are marked with an asterisk (*) in the above table. The drop test energy required to break



Figs. 5 and 6

these three specimens was 4,920, 7,380 and 10,250 foot pounds respectively.

If an average of these results is taken, it will show an increase in strength of about 10 per cent above that of the three similar breaks of the tire in the natural condition as given in the table. At the same time, it will appear that there was no change in the strength of the tension test specimens. This is due to the effect, already noted that the electric welding process produces only a very narrow hard area, that did not reach down to and was not included in that portion of the metal from which the tension test specimens were obtained. On the other hand, experience with other samples of medium carbon steel has shown that this narrow hard area has a low resistance to vibratory strains and contributes to an early failure of the tire.

Tension test specimens were cut from each tire at the points indicated on the diagram.

Attention has already been called to the fact that the

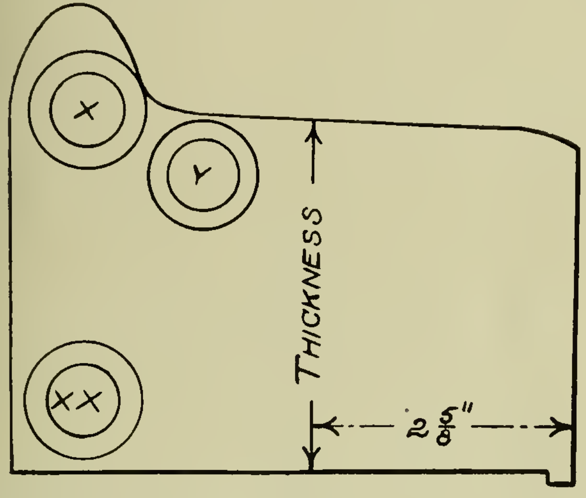


Diagram Showing Points at Which Test Specimens Were Cut From Each Tire

change of grain structure, due to the heating improved the tension properties of the metal.

There were thirty-nine tension tests made in all. The average of these gave averages as follows:

	Points X	Points XX	Points Y
Yield point, lbs. per sq. in...	61,222	52,897	56,860
Ultimate strength, lbs. per sq. in.	121,851	115,733	117,659
Elongation, per cent.......	12.54	13.78	13.45
Reduction of area, per cent..	20.43	20.58	21.58

There were some wide variations in the individual items on which these averages were based. For example: The ultimate strength ranged from 85,200 to 172,000 lbs. per sq. in. for the point X, from 98,800 to 154,300 lbs. per sq. in. at XX, and from 100,200 to 132,900 lbs. per sq. in. at Y. The respective ranges for the yield point ran as follows:

At X from 39,000 to 106,500 lbs. per sq. in.
At XX " 40,800 " 101,300 " " " "
At Y " 46,800 " 72,200 " " " "

The ranges for elongation were:

At X from 1.0 to 22.0 per cent.
At XX " 7.0 " 22.0 " "
At Y " 7.0 " 22.5 " "

The ranges for the reduction of area were:

At X from 2.1 to 39.2 per cent.
At XX " 8.6 " 48.3 " "
At Y " 8.6 " 45.8 " "

The requirements as to chemical composition according to the specifications of the railroad are:

	Per cent.
Carbon	
Class A, Passenger	0.50 to 0.70
Class B, Freight	0.60 to 0.80
Class C, Switching	0.70 to 0.85
Manganese	not over 0.75
Phosphorus	not over 0.05
Sulphur	not over 0.05
Silicon	0.15 to 0.35

The averages of the forty analyses that were made were as follows:

Carbon	0.60	per cent
Manganese	0.55	per cent
Phosphorus	0.047	per cent
Sulphur	0.049	per cent
Silicon	0.23	per cent

In the individual items the ranges were:

Carbon	from 0.30 to 0.74	per cent
Manganese	from 0.44 to 0.64	per cent
Phosphorus	from 0.035 to 0.066	per cent
Sulphur	from 0.038 to 0.06	per cent
Silicon	from 0.19 to 0.31	per cent

After a careful comparison of the data obtained the conclusion was reached that of nine tires for the breakage of which a cause is assignable, four broke due to strains caused by gas welding, three due to cutting the retaining lip with gas, and two from old flaws.

The results also show that the gas cutting and both the gas and electric welding processes as applied to the steel tires, thus far tested, set up internal stresses in the metal, and that these stresses lower the resistance of the metal to shock and contribute to the failure of the tires both while being applied and in service.

Railroads Largest Steel Buyers in 1923

Railroad consumption of steel again dominated all other requirements in the United States in 1923. The figures of tonnages absorbed reveal the remarkable results of the aggressive efforts the carriers are making to rehabilitate themselves for transportation service. About one-third of the total output of the steel works of the country last year was applied to railroad purposes.

Steel companies representing three-fourths of total capacity during 1923 shipped 30.78 per cent of their output either to railroads direct or for manufacture into railroad equipment or appliances. The amount is reported to have been 6,935,653 tons. On this basis the calculated total of all steel shipped by all steel companies for direct or indirect railroad consumption during 1923 was 9,437,235 tons. Railroad consumption was 66½ per cent larger than in 1922.

Second in the record of consumption was the tonnage used for structural purposes, reflecting the great increase in building activity in 1923. The approximate total was 4,835,900 tons, representing 15.77 per cent of the total steel output in the year.

Production of automobiles and trucks in 1923 was the largest on record, and consumption of steel in this division shows a large gain. The amount was 3,094,100 tons, representing 10.09 per cent of the total steel output. The increase in tonnage over 1922 was approximately 50 per cent.

Consumption by oil, gas and water enterprises in 1923 amounted to 3,314,900 tons, or 10.81 per cent of the total. The amount was only 220,800 tons larger than the steel that went into motor car manufacture.

The Compound Locomotive in America

By Geo. L. Fowler

The story of the introduction of the compound locomotive in America is a peculiar one and differs radically from that relating to the work done abroad. So radically in fact that it must have impressed European railroad officers at the time with a very poor opinion of the progressiveness of their brothers in the United States.

The first compound locomotive of which there is any record was built along in 1868 or 1869 for the Erie Railroad. An ordinary eight-wheeled engine having been changed into a four-cylinder compound at the Buffalo shops of that company. It was not a success and was soon reconverted to a simple machine. No records of tests are available and the bare statement of its existence is all that remains.

The real interest in the development of the compound locomotive began about 1889, after the work was well under way in Europe. The engines built for the Northern of France, the State Railways of Hannover, and the London and Northwestern, had been put into service and reports of coal savings of from 15 to 25 per cent caused builders to look about with the object of gaining business by offering engines of the new design. It is well known that the early designs were protected by patents and a number of these were offered to American builders. Few, if any, sales were made, however, because of the high prices asked both for the outright sales of the patents and for royalties. In fact one of the builders here declined the consideration of a patent on the ground that they could build the intercepting valve of their own design complete for a lower price than the royalty asked on the patent originating abroad. Under these conditions there was a stimulus among American designers to patent compound locomotive intercepting valves and other parts to the exclusion of those that had been tested in Europe.

It is here that the radical difference between the conditions surrounding the introduction of the compound locomotive in the United States and Europe exists. In Europe the work of designing and introduction was done by the railroad officials. In the United States the work was done solely by the locomotive builders. In Europe the railroad officials were anxious to secure the possible savings that could be obtained by the use of the compound system and devoted time and money to the working out of these ends. In the United States the officials manifested an almost absolute indifference to the success or failure of the new design. While they did not block the way, other than by their indifference, they gave little or no assistance and manifested but scant confidence that the "thing would work at all." Had it not been for the persistent labors of a few builders it is safe to say that the compound locomotive would not have been introduced at all. Of course there were some railway officials who believed in the type and did what they could, but the great majority were unbelievers.

The builders were interested because it offered a field for the cultivation of a monopoly. The building of simple engines of any design was open to the competition of the world; but the parts of a compound locomotive could be patented and a successful arrangement be so protected as to afford a practical monopoly to the designer. The result was, that each and every builder put forth designs of his own and succeeded in getting a few orders. The leaders in the movement were the Baldwin Locomotive Works, the Richmond Locomotive Works and the Schenectady Locomotive Works. The first put out a four-cylinder machine with a high and low pressure cylinder outside the frame on each side and the two last offered two-cylinder engines, with cylinders outside the frames.

These promoters evidently believed in their wares and we find their representatives, especially those of Baldwin and Richmond advocating them in season and out. They offered many inducements and their guarantees were gilt-edged. But the railroads were lukewarm. In the public meetings of the American Railway Master Mechanics' Association, the representatives of the builders were insistent and persistent in advocating the merits of their system, while those of the railroads gave a half-hearted assent to what was said, an approval that was but little better than open hostility. In private, true sentiments came out; and, in the great majority of cases these were to the effect that, while the compound locomotive might affect some slight saving in fuel the other increased expenses, for repairs, oil and delays would more than compensate for the slight gains, and it would be just as well to let someone else do the experimenting and stick to the simple engine in the meantime.

Sometimes, too, such unexpected ignorance of the principles of compound action would develop that it would prove and absolute check to any progress in its introduction. As an example of an extreme case I may quote from a conversation between the representative of a locomotive works and the superintendent of motive power of one of the largest roads of the country, at which I was present. The locomotive man was endeavoring to persuade the superintendent of motive power to take a compound locomotive for trial at no expense to himself, and after putting forward his best arguments as to coal saving, economy of repairs and reliability, received this reply:

"It is useless to talk about this thing, there is nothing in it, and we will not try it. Now, for example, what is the back pressure on your high-pressure cylinder?"

He was told that it was about 90 lbs., when he went on:

"There, that's just it, that high pressure is what kills it. If you could put a condenser between the high and low-pressure cylinders, as they do in marine work, and remove all of that back pressure, there would be something in it, but so long as the engine must be run without such a condenser, I have no use for the compound locomotive."

It is, perhaps, needless to add that the advocate of the compound locomotive, realizing the uselessness of further missionary work in that direction, was silent.

One more example to emphasize the difficulty attendant upon the introduction of the compound may be found in the form of guarantee offered by one builder. It was offered to put in one compound locomotive in an order, for five hundred dollars more than the price of a simple engine, and to wait for the payment of one-thousand dollars of the total amount until the engine had saved five hundred tons of coal over a simple engine of the same class in the same service as per the records of the railroad company. At the same time the builder guaranteed a coal saving of 15 per cent. and no extra cost for repairs; while, if these guarantees were not fulfilled they stood ready to remove the compound cylinders and replace them with simple ones at no expense to the railroad company. Yet despite the favorableness of this offer it was more than difficult to persuade a railroad man to accept it. From all of which it will appear that the American railroad officer did not stand forth as an earnest advocate of the compound locomotive in its early struggle for recognition.

The period when the discussions were the most intense ran from about 1891 to 1896. By that time the type has established itself in certain quarters and the strenuousness of the advocacy was somewhat relaxed. To show the progress in the output of compound locomotives the following table compiled from the reports of the locomotive companies may be regarded as quite accurate. According to the reports the number of compound locomotives built annually from 1889 to 1903 were as follows.

1889—2	1897—142
1890—9	1898—348
1891—100	1899—371
1892—263	1900—550
1893—237	1901—669
1894—38	1902—800
1895—73	1903—410
1896—195	

This cannot be said to be a rapid growth and even these few engines did not all hold their own as compounds but many of them were reconverted to simple machines.

The American railroader of that time feared complication and he would sacrifice many evident advantages for the sake of securing that one which he considered of the first importance—simplicity of construction. The result of which was that the four-cylinder compound locomotive had reached a high state of development abroad before any work was done along the same lines in the United States. The type had a few advocates, however, and for a few years after 1900 it has come to be viewed with some favor, and in 1903 there were 49 examples built and put into service.

Such then is the outline of the struggle to introduce the compound locomotive upon American railroads.

It would be quite impossible as well as out of place to undertake a review of all of the types of compound locomotives that were built. With the exception of the four-cylinder engine of the Baldwin Locomotive Works, the majority of builders confined themselves, in the early days, to the two-cylinder type. These latter varied among themselves merely in the form of the intercepting valve, by which the working of the engine was converted at the start from simple to compound action either automatically or manually according to the style of the design. There were a few tandems built, but they were so few as to lie almost beyond the pale of consideration.

Mention has already been made of the engines put out by the works of the Baldwin, Richmond and Schenectady Locomotive Works. The first was a four-cylinder machine with the piston rods of both the high and low pressure cylinders on a side, taking hold of the same crosshead, and operated by a single valve.

The valve was of the piston type and was worked by the Stephenson link as were all other compounds, with very few exceptions.

The Richmond and Schenectady engines differed only in the form of their intercepting valves. Each of the engines were arranged to start as a simple engine and to run in that condition indefinitely or to be converted to compound action either manually or automatically at the will of the engineer.

A number of designs of four-cylinder machines were brought out, they had cranked axles and one set of cylinders inside the frames, and then came that epoch-making locomotive built for the Baltimore & Ohio R. R., the Mallet compound that at the time was the heaviest locomotive in the world.

In regard to the operation of compound locomotives it was shown by repeated tests that there was invariably a saving of coal. This ran from 10 to 35 per cent according to the condition of the locomotives competing. An average of from 18 to 20 per cent is not far from what might have been expected with locomotives in fair running condition and at work in ordinary every day service. There was a variation of opinion as to whether the repairs were more on the compound than on the simple engine but the probability is that there was not much difference between the two.

The growth of the cylinders on the American engines was so rapid during the period of this development and that, in order to keep pace with this growth, the low-pressure cylinders of the two cylinder compound had to be made abnormally large, rising to a diameter of 36 inches in some instances. This not only rendered the proper designing of the reciprocating parts very difficult but widened the engine out to the full limits of the clearances of the permanent way. The result was that it was necessary to call a halt in the increase of cylinder diameters and look for other means to meet the demands for an increase of power. This was done by doubling the number of cylinders and the establishment of the four-cylinder machine with crank axles. Illy disposed as was the sentiment of the railroad community to the acceptance of the increased complication involved; the advantages in coal consumption and balance were so evident, especially in the case of the fast express service, that type at one time seemed likely to gain a firm foot-hold.

To be sure, it was never extensively introduced but after 1900, a number were built.

Taken as a whole the railroad community may be said to have been converted from the position of mild resistance and open opposition to the introduction of the compound locomotive, to an acceptance of its good points, an appreciation of its merits and a desire to try it.

Then just as the compound locomotive seemed, in the eyes of its advocates, to be settling itself in the saddle and was expected to stand or fall on the record of its own performances, we began to receive rumors of a rival in the form of superheated steam.

These early rumors came at a time when the acceptance of the compound locomotive seemed assured, after the struggle that had been made against the reluctance of railroad officials.

There was always much uncertainty as to the value of the compound, for there was the added first cost, and the probability of added maintenance charges to be weighed against the possible coal saving.

Then the superheater seemed to more than rival the coal saving of the compound until it finally drove it from the market with the exception of the Mallet which has increased in numbers far beyond the wildest expectation of its designers at the start.

Whether the compound other than as a Mallet will rise again from the ashes of defeat in its competition with the superheater, is a matter for the future to decide, and already as indicated in the Decembr 1923 issue of this paper, a vigorous attempt is to be made to bring about such a revival.

15.2% Locomotives Need Heavy Repairs

The railroads on December 15 had 10,873 locomotives, or 16.9 percent. of their ownership, in need of repair, according to the American Railway Association. This was an increase of 301 since December 1.

Of the total number 9,804, or 15.2 percent., were in need of heavy repair, an increase of 227, compared with the number in need of such repair on December 1. There were also 1,069, or 1.7 percent., in need of light repair on December 15, 74 locomotives more than on December 1.

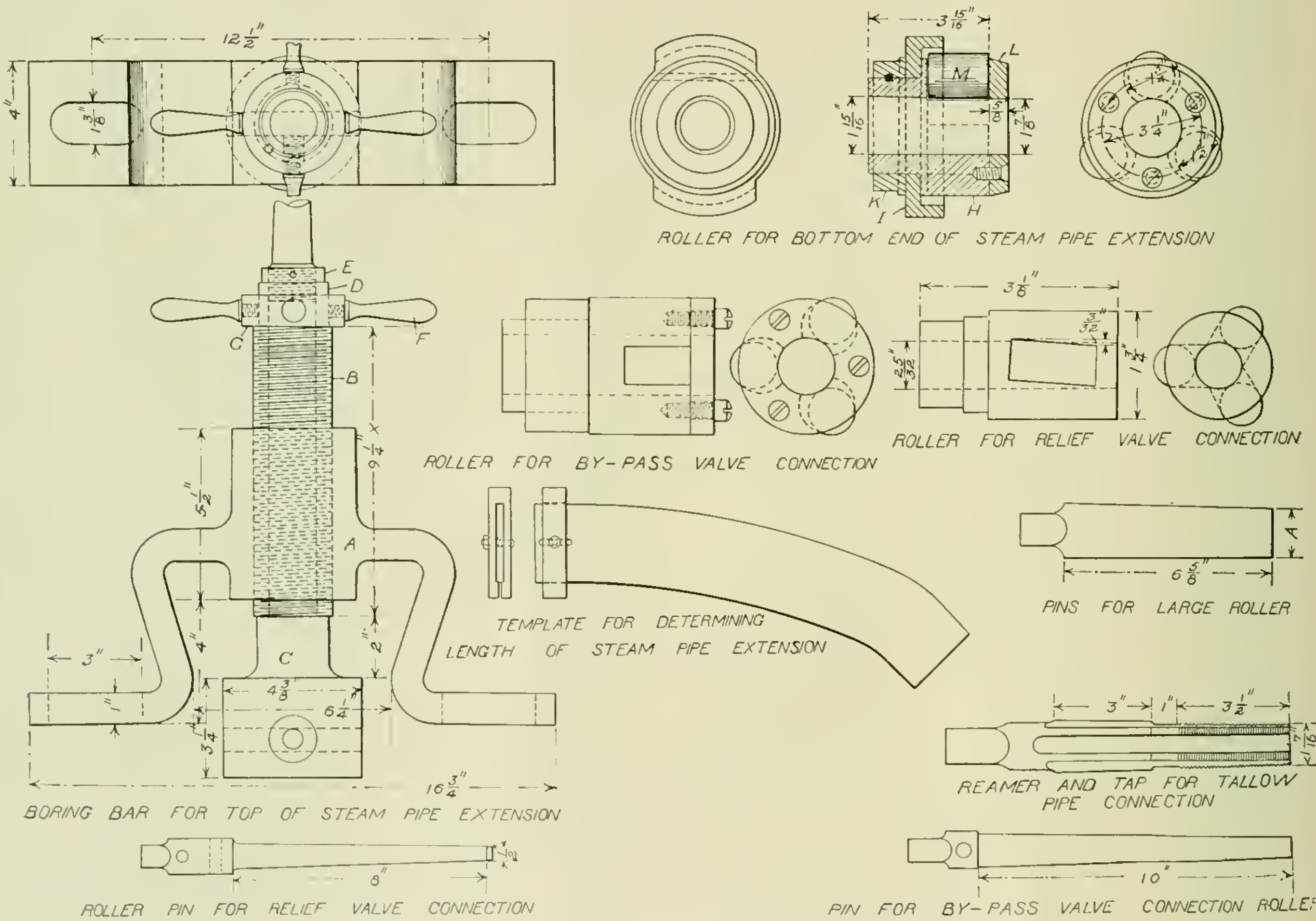
Shop Kinks

Tools for Facilitating Shop Work Developed on the Chesapeake & Ohio Ry.

Special Tools for Reclaiming Cylinders

Considerable trouble has been experienced on certain types of heavy locomotives with the cracking of internal steam pipes or passages of the cylinders. As these passages are usually well down in the interior of the cylinder casting, it is often very difficult if not impossible to get at the crack in order to weld it. With cylinders costing what they do today, it is an expensive thing to discard an otherwise perfectly good cylinder for a small crack feet have a total spread of 16¾ in. and are drilled with 1⅜ in. by 3 in. slotted holes spaced 12½ in. from center to center. This gives sufficient leeway to permit the feet to be slipped over the steam pipe studs and be thus bolted fast to the cylinder, without removing from the smokebox.

The boss or nut *A* that is welded in with the base is cut with 10 threads to the inch to take the feed sleeve *B*.



Special Tools Used on the Chesapeake & Ohio Railway for Reclaiming Cylinders

that does not impair its strength in the least, but which renders it useless for further service.

In order to avoid this waste, a method of cylinder reclamation has been developed on the Chesapeake & Ohio Railway; and tools made for the execution of the work that are worthy of careful attenion.

The principle upon which the repairs are made is that of substituting a wrought iron pipe for the original cast passage and placing it inside of the same.

To do this both ends of the passage are bored out to fit the pipe and the latter is put in place and then rolled out to make a steam tight joint. In this the flanges for bolting the smoke box steam pipe are not disturbed, and the studs for the same are used for holding the boring tool in place while the work is being done.

The base of the device *A* is made of 1 in. by 4 in. flat steel with a nut 5½ in. long welded into its center. The This sleeve has a bearing at the bottom against a shoulder on the spindle *C*. At the top the feeding handles *F* are screwed into a collar *G* which is fastened to the sleeve, and by which it is turned.

The interior of the sleeve is bored out smooth to receive and serve as a bearing for the spindle *C*. The latter has an enlargement at the lower end 4⅜ in. in diameter and 3¼ in. deep, which serves as a tool holder. It is drilled to a diameter of ¾ in. for the tool and tapped for a ⅝ in. set screw to hold the same. There is an enlarged portion 2¼ in. in diameter at the bottom which forms the shoulder, already referred to, against which the sleeve *B* has its bearing. The spindle is turned to a diameter of 1½ in. for a length of 11⅛ in. The upper 1⅜ in. of this cylindrical portion is cut with 12 threads to the inch to take the bearing washer *D* and the nut *E*, the latter being pinned to the spindle to prevent unscrewing. Finally the upper 6 in. of length of the spindle is turned to a No. 4 Morse taper to fit the socket of the air motor that is used to drive the tool.

This spindle, with the attachments as described above is used for boring out the steam pipe extension. For boring out the old steam passages in the cylinders an extension bar of the same construction is used. The difference consists solely in the length; the threaded portion of the feed sleeve *B*, being 21⅞ in. long instead of 9¼ in.

The method of using the device is to first bolt it in place, and, then after the cutting tool has been set, drive it with an air motor and feed into the work by hand.

After the boring has been completed, it is well to make a wooden template of thin material of the shape of the steam pipe extension as shown by the sketch. When the pipe has been cut and fitted in place, it is rolled out against the bored out portions to make a steam tight joint. A specially designed roller is used for the bottom of the steam pipe extension.

This consists of a body *H*, which is bored for the three rollers. The spaces so bored are on a circle of 3¼ in. in diameter, and are themselves 1¾ in. in diameter. The rollers have a diameter of 1½ in. The rollers lie loose in these sockets and are held in place by the ring *L* which is fastened to the body *H* by three ⅜ in. machine screws. The body is 3 15/16 in. long and the ring is ⅝ in. thick. The body also carries a guard *I* to retain the apparatus in place and this is held by a collar *K* which is pinned in place. The taper of the hole runs from 1 15/16 for the outer end of the body to 1⅞ for the ring.

There are three pins for this roller. The tapered portion is 6⅝ in. long and is made with a taper of ½ in. in 12 in. and the small end marked *A* is 1 7/16 in., 1½ in. and 1⅝ in. in diameter repectively.

A special roller is also used for the by-pass connection which is inserted and rolled to fit. It is of essentially the same construction as that already described. The difference lies, for the most part in the dimensions. The sockets for the rollers are bored to a diameter of ⅞ in. and the rollers are ¾ in. in diameter and 1 in. long. Instead of using three pins to force out the rollers consecutively, a single pin 10 in. long with a taper of ⅜ in. in 12 in. is used.

A third roller is used for rolling out the relief valve connection. In this the rollers are 1⅜ in. long and are set at an inclination of 3/32 in. with the axis of the body. A single expanding pin is used, which has a length of taper of 2 in., a taper of ⅜ in. in 12 in. and a diameter of ½ in. at the small end.

Special taps and reamers are also provided for making the tallow pipe and relief valve connections. The tap for the relief valve is simply a 2 in. pipe tap with a shank 5 in. long. There is a plain fluted reamer of 12 flutes 10⅜ in. long with a taper of ½ in. in 12 in. and 1⅜ in. in diameter at the small end, and a combination tap and reamer. In this the tap is tapered and has a length of 3½ in. It is 1 7/16 in. in diameter ⅜ in. from the small end and is cut to 12 threads to the inch. There is, then, a gap of 1 in. followed by a reamer 3 in. long; both tap and reamer being on a taper of ½ in. in 12 in.

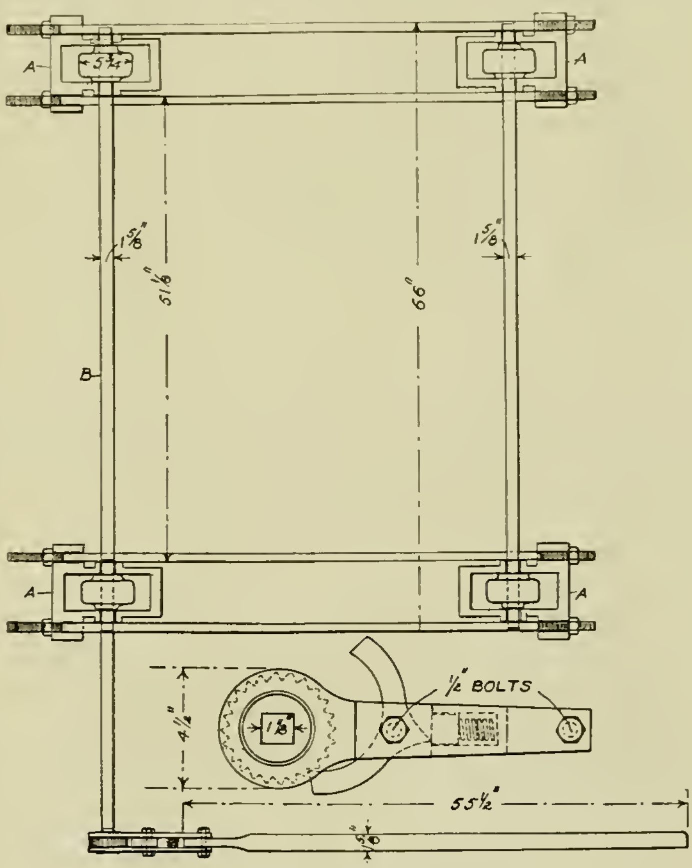
The salvaging of cylinders by this process has been very successful and there have been no failures afterwards. As to the saving to be effected by such work each engineer can judge for himself. It costs from $50.00 to $60.00 to salvage a cylinder by this process and this is to be considered as the offset against a new cylinder.

Driving Mechanism Air Valve Setting Machine

The Chesapeake & Ohio have two types of driving mechanisms for turning the wheels when setting the valves. One is the old hand operated device with the shoes *A* resting on the rails, and carrying the roller-bearing shafts, which are drawn together by the units, on the connecting bolts, until the wheels are lifted clear of the rails. The main driving shaft *B* is then turned by the usual ratchet with the lever, and may be driven in either direction by throwing the pawl.

But, as hand turning is a slow process, an air-driven device has been designed and put into successful operation. It is driven by an air motor through a worm and gear, so that the wheels may be rapidly revolved.

There are two built-up end pieces *C*, each made of two pieces of steel of the shape shown, bolted together. They are each bored to 2 in. in diameter to take the boss of the worm wheel which thus serves as a journal for the latter. At the top the two valves are bored on the dividing line to receive the brass bushing *D* which serves as a bearing for the worm shaft *E*. The two end pieces *C*



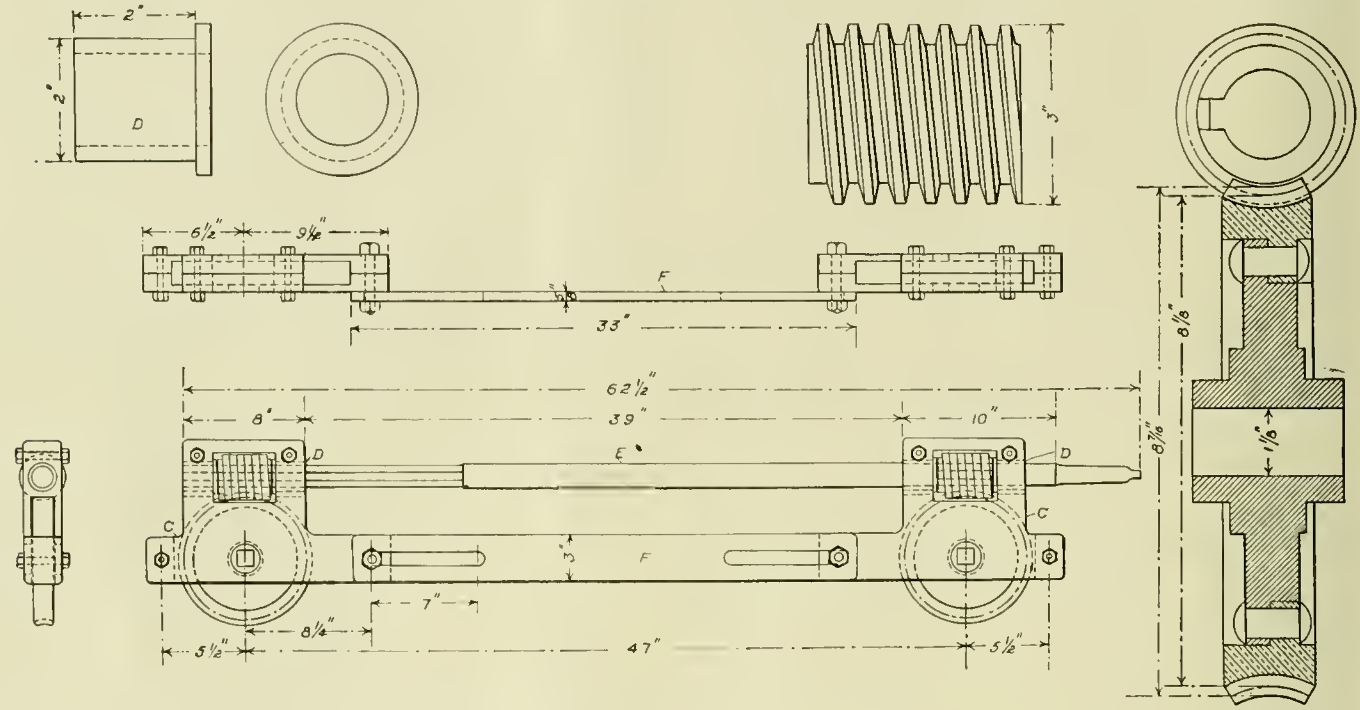
Valve Setting Machine

are held together by the flat bar *F* of ⅝ in. by 3 in. steel, which has a slotted hole 7 in. long at each end, by which the distance between the end pieces can be adjusted.

The worm shaft *E* is cut down from a diameter of 1⅝ in. to 1½ in. at each end to form the journals. At one end this reduction extends back for a distance of 18 in., and is cut with a 3/16 in. by ½ in. keyway. A gib key is let into the worm, and this slides in the keyway. So that when the distance between the end pieces is adjusted by means of the bar *F*, the shaft *E* automatically adjusts itself to the change by sliding to and fro in the left hand worm gear. At the other end the shaft terminates in a No. 4 Morse taper drill shank, by which the connection to the air motor is effected.

The worm gear was originally made of solid cast iron.

But the wear was such that it has been changed and now is made with a steel center and a bronze rim rivetted in place. This rim alone is replaced when worn. It is 8⅛ in. in diameter at the pitch circle and is cut with fifty-one teeth having a circular pitch of ½ in. The hole at the center of the gear is 1⅛ in. square and is made to fit over the squared ends of the roller shafts of the ordinary



Driving Mechanism for Valve Setting Machine

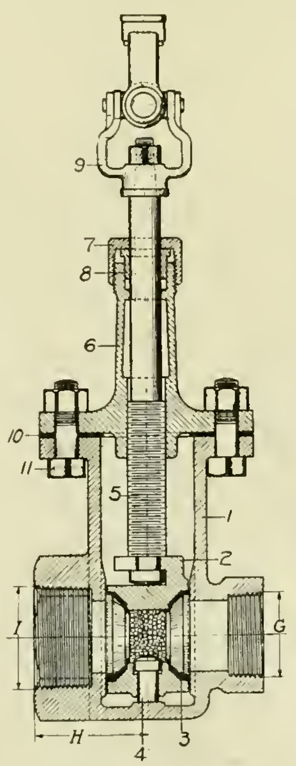
turning mechanism. When these have been placed in position and drawn together so that the wheels are clear of the rails, the centers of the worm gears are adjusted to suit; they are slipped over the squared ends of the shaft, and the whole is ready for operation.

The Nathan Compensated Blow-Off Valve

To eliminate trouble due to leaky blow-off valves and to reduce blow-off valve maintenance the Nathan Manufacturing Company of New York has developed a new type of compensated valve that provides absolute and lasting tightness of the valve and practically eliminates repairs and replacements.

In the usual type of blow-off valve slight uneven wear on either the valve disc or seat results in leakage and necessitates replacement. This is entirely eliminated with the Nathan Compensated Valve as any unevenness of wear is entirely compensated for and the valve will remain tight. Moreover it does not depend on the action of steam or fluid pressure to keep it tight.

This valve is opened and closed in the same manner as the ordinary gate valve. Instead of a wedge action, however, the valve discs are forced outward against their seats by a uniform pressure produced by small steel balls or shot. The action of the shot within the cage is similar to the action of the fluid in which the pressure is exerted uniformly over the face of the discs regardless of their inclination or shape. These steel balls are made of non-corrosive steel and are placed in the cavity of the carrier (2) within the body of the valve. This carrier also supports the two valve discs. The carrier is raised and lowered by means of the valve spindle (5) which is threaded into the cap of the valve (6). At the bottom of the carrier is a pressure knob or plunger (4) which is forced into the cavity containing the balls when the carrier reaches a point near the bottom of its travel. When this plunger pushes upward it displaces the balls forcing them against the valve discs producing a uniform pressure. In this way the discs are forced against their seats no matter what wear has occurred. Regardless of whether the valve disc seats are inclined to the right or to the left, or upward or downward, and even if it is different on the two faces, the uniform pressure on the valve discs will compensate for this and the valve will remain tight.



Nathan Compensated Blow-off Valve

The Nathan Compensated Blow-off Valve is built with threaded ends or with a flange connection for one side. Its construction throughout is very simple and parts may be replaced with ease. The outlet of the valve is tapped for the attachment of pipe and hose to remove the material blown from the boiler. When fully open the carrier and the discs are raised into a space within the body of the valve forming a straightway for the discharge of material. On account of the discharge across the opening, scale will be washed through the valve, yet even if a scale does remain in the bottom of the valve it can not interfere with the closing of the valve nor the forcing of the discs against the seat.

The tightness of the valve is independent of the action of the steam or other fluid and depends merely on the force with which the plunger or pressure knob is driven in the cavity filled with shot.

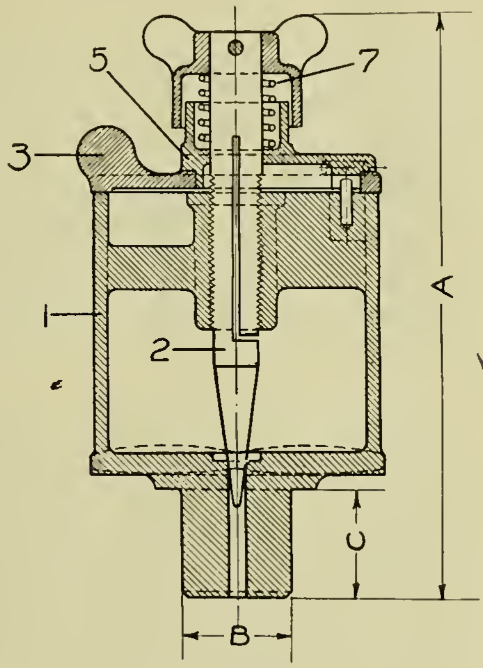
The universal joint at the top of the spindle is furnished when it is desired to control the blow-off valve from the cab or the running board, but a handle may be supplied if an extension is not needed.

New Oil Cup for Guides and Valve Stems

By maintaining a uniform oil feed while the engine is in motion, providing for easy, quick filling, preventing loss of oil cup cover and preventing entrance of dirt into the oil reservoir when removing the cover for filling the Nathan Oil Cup recently introduced by the Nathan Manufacturing Company of New York fill a very definite need.

Uniform feed is controlled and maintained by the spindle (2) much in the usual manner except this spindle is made slightly oversize and slotted. This oversize, together with the spring under the winged cap creates sufficient friction to preclude all possibility of the spindle turning due to vibration. The uniformity of oil feed once the spindle is set is assured.

By the method of securing the cover to the body of the oil cup ease of filling is secured yet the cover cannot be lost off or dirt get into the oil. This cover (3) swings in either direction around fixed cup (5) by pressing against the projecting fin on the back. When swung away from closed position a liberal opening is exposed for filling the cup. When the cover is returned to closed position it is caught by means of a clip and positively locked against opening. The cover in opening slides over the finished surface of the top of the oil cup body thus any dirt that might adhere to it is wiped off on the outside of the cup. The cover cannot be removed without first removing the spindle and it, therefore, cannot be lost in service.



Oil Cup for Guides and Valve Stems

To fill and regulate this oil cup does not require the removal of a single part.

Malleable iron is used in the manufacture of the Nathan Oil Cup because of its lower cost and less likelihood of being removed from standing locomotives in yards or roundhouses. All parts are made interchangable and carefully inspected.

The Nathan Oil Cup is economical in first cost, reliable and durable in service and economical in the use of oil.

The Average Life of Locomotive Engineers

That the locomotive engineer is as long lived as the average American in spite of his hazardous occupation is shown by a "life table" recently prepared by the statistical division of the Metropolitan Life Insurance Company from figures compiled by the Locomotive Engineers Mutual Life and Accident Insurance Association. According to the table, the average engineer of 28 may count on living until he reaches the age of 69.

This is said to be the first time that a "life table" has been prepared and published from adequate data for a specific American industry.

Despite the hazards of the engineer's calling, insurance figures show a substantial decline in mortality among men in that occupation during the past ten years. Between the ages of 31 and 55, the declines ranged from 32 to 44 percent. Beyond the age of 55, the figures varied but this reflected the small number exposed to risk.

A decline in the accident death rate from 318 per 100,000 in 1912, to 167 per 100,000 in 1922, show how great has been the improvement in safety provisions for the operating personnel of American railroads and accounts for a large part of the saving in mortality at the age range from 31 to 55 years, according to the insurance report.

Offsetting the drop in the accident death rate, there was noted an increase in the mortality rate for organic heart disease, cerebral hemorrhage and apoplexy. Bright's disease showed a decrease of 36 percent. for locomotive engineers during a given period as compared with a decrease of 23 percent. for males in the general population.

Westinghouse Brake Adopted for European Railways

An international commission, composed of representatives of France, Belgium, Great Britain, Greece, Rumania, Yugoslavia, and Czechoslovakia, has adopted the Westinghouse triple "L" valve brake as the standard continuous brake system to be used in European countries. This action was in accordance with Article 370 of the treaty of Versailles, by which Germany undertook to introduce on freight trains a continuous brake of a type which might be adopted by the victorious powers within 10 years following the adoption of the treaty.

The delegate from Yugoslavia, inventor of a system of brakes widely used in that country, opposed the adoption of a uniform brake system. He was supported by the Czecho-Slovak delegate, who claimed that the changes required in his country would cost 400,000,000 francs, an expenditure which his country was unwilling to undertake.

The Westinghouse brake stood extensive and exhaustive tests by the French commission appointed to consider the type of brake most suitable for use on French cars, and received the commission's unanimous approval. As a result, this system has been adopted by the international commission, with the proviso that the countries involved are free to adopt any brake which can be used contemporaneously with the Westinghouse brake. It is maintained that the use of a variety of brakes as agreed upon is an improvement over existing conditions, but that the several systems will be more expensive to maintain than a single system.

1924 Brussels Commercial Fair

The Fifth Commercial and International Brussels Fair will be held from April 1 to April 16, 1924. The four preceding fairs have proved conclusively the indispensable usefulness of this organization.

The Brussels Samples Fair is entirely and solely devoted to industry and commerce: it is not a commercial enterprise, and the price at which it rents its worldwide publicity is lower than the cost of local advertising: frs. 1050 (about $50.00) is the maximum rent for a stand of 12 square yards, entirely decorated and furnished.

Snap Shots—By the Wanderer

There is an old story of the days of the introduction of the Wootten boiler, that, on one occasion, when an engine ran out of coal, the enginemen loaded the tender with cinders and went on his way undisturbed except by the delay caused by the time consumed in the loading. The story seems good enough and plausible enough to be true, if we accept a statement recently made by the superintendent of motive power of one of the anthracite roads to the effect that investigations have shown that about four per cent of their fuel is wasted in sparks and cinders. Of course this does not include the waste from hot gases.

It has also been found that the sparks and cinders have a calorific value of about two-thirds the same quantity of coal.

The moral is the old one, with which every locomotive man is familiar that the variables due to smokestack wastes will more than counterbalance any minor saving that may be made by improved appliances.

Speaking of the coal consumption on the anthracite roads, naturally draws atention to the variety of coal used. Pocahontas is generally conceded to be the best steam coal that is mined in this country. With about 15 per cent of volatile matter, nearly or quite 80 per cent of fixed carbon and a little more than 4 per cent of ash, we have a fine combination that is observing of due respect. From this fine combination we drop down through the various grades of Thacker, Pittsburgh, Ohio, and Illinois coals until we reach the young lignites of the far west. The wonder is, with these variations we can make any approach to standard practice or standard appliances.

It has just been suggested that the Interstate Commerce Commission establish a fixed ratio between oil and coal, for the reports of the oil burning roads. The establishment of such a ratio would be very easy if they would say what coal and what oil. If we should pick upon Bakersfield oil and Pocahontas coal we would probably have a ratio that would be very misleading to those who were using Oklahoma oil and Illinois coal. We can say of coal as Macbeth said of dogs and men:

"Ay, in the catalogue ye go for men;
"As hounds and grey hounds, mongrels, spaniels, curs,
"Shoughs, water-rugs and demi-wolves are clept
"All by the name of dogs: the valued file
"Distinguishes the swift, the slow, the subtle,
"The housekeeper, the hunter, every one
"According to the gift which bounteous nature
"Hath in him closed, whereby he does receive
"Particular addition, from the bill
"That writes them all alike, and so of men.
And so likewise of coal.
As dust and buckwheat, pea, nut and culm,
Egg, stove and run-of-mine are clept
All by the name of coal; the valued file
Distinguishes the lump, the Pittsburgh and Pocahontas,
The high steam and coking coals, every one
According to the heat which bounteous nature
Hath in it stowed, whereby it does receive
Particular additions in the bills
That writes them all alike."

So while it may be an easy thing to ask that a ratio be fixed between oil and coal. We ask at once, what oil? What coal? How used and where?

We all know that the kind of coal is no mean factor in every kind of service. Is there a superintendent so new to his place that he has never read: "Engine failed because of poor coal," or "No—lost thirty minutes because of poor coal"? Don't we know that the kind of coal is a controlling factor in engine drafting? Perhaps a little story may illustrate the point.

Many years ago when the extension front had full swing in locomotive design and our machines were made to look like monster pouter pigeons, we, too, were caught in the swirl; but could not make it work. We followed recommended plans but the fires refused to burn, the boilers failed to steam and trains went haltingly over the road.

Then we had a visitor who told us how finely the extension front worked with him. We told our woes and he sent us prints of his arrangement. We copied it, but it would not work. So we readjusted the diaphragm, rearranged the netting; did a little tinkering with the height of the exhaust nozzle, and so before long had extension fronts that were working with the best of them. How good that was the old timers are best prepared to say.

Then came another man with a tale of woe, much longer and more lugubrious than our own had been. We showed him what we had done and told of our experiences. "Now, I will copy you," he said. He did, and landed just where we had been. His engines were not all that they should be.

Then he began the tinkering as we had done, and by making changes here and there achieved success.

Now why was this when our engines were nearly all alike? Simply coal. The man who tried to help us out was burning Pittsburgh. We were using Hocking Valley and the man we tried to aid was firing Illinois.

So I say again, on what are we to base the coal-oil ratio? Who can say?

To change the subject, I saw a curious case of misapplied care in a passenger car the other day. The bell cord came in over the center of the door and then ran out and along the base of the monitor roof. The carriers at the ends were provided with rollers that were set horizontally, as was perfectly proper in order to take the side pull caused by the change in the direction of the cord. But all the others were put in the same position though the motion of the cord through them was straight and it rested on the bottom. The rollers were, of course, inoperative, and the cord, which was in almost constant use, was wearing itself out and a nice little groove into the metal of the fitting.

It was a case of thinking, but not thinking enough, like the cartoonist of a comic weekly paper that recently represented the good Ship of State sailing along under skillful pilotage with a bright port light in the starboard rigging, a fact that spoke volumes for the skill but mighty little for the care and judgment of the pilot.

The moral of which is that, when you think, there is no objection to thinking quickly, provided only you think enough.

Thinking quickly is probably closely allied to acting quickly, and this brings us to the personal equation. Can it be lowered? Is there any way by which a man who normally requires from a second and a half to five seconds to transmit or give a signal, can reduce his time to a half second? If there is, and it can be made to work, a good deal of time lost by railway trains, especially on the elevated roads and in the subways, would be saved.

Topics for General Foreman's Convention

At a meeting of the International Railway General Foreman's Association held last month, in Chicago, for the purpose of selecting topics for discussion at their annual convention in 1924, the following subjects were decided upon:

1—Terminal Inspection and Running Repair Costs, and Repair Work Practices.

2—Steel Car Repair Facilities and Methods of Repairs to Various Parts of Passenger and Freight Cars.

3—Methods of Maintenance of Superheaters, Feed Water Heaters, Locomotive Stokers, and Boosters.

4—Labor Saving Devices, Other Than Those Sold or Patented and Shop Organization.

Subsidiary Paper: No. 1—Making Craftsmen Out of Young Men.

Subsidiary Paper: No. 2—Education and Supervision of Employees—Including Safety First and First Aid.

Notes on Domestic Railroads

Locomotives

The Canadian Pacific Railway is inquiring for from 10 to 15 Mikado type locomotives.

The Western Pacific Railroad is reported to be in the market for 10 locomotives.

The St. Paul & Tacoma Lumber Company is reported to have placed an order for one locomotive with the Baldwin Locomotive Works.

The Toledo, Angola & Western Railway has purchased one Mikado type locomotive from the American Locomotive Company.

The Texas-Mexican Railway has ordered a 4-6-0 type locomotive from the Baldwin Locomotive Works.

The Webb Logging & Timber Company has ordered one 90-ton Shay locomotive from the Lima Locomotive Works.

The Valley & Siletz Railroad has ordered one locomotive from the H. K. Porter Company.

The Canadian National Railways is inquiring for five 2-10-2 type locomotives.

The New York, New Haven & Hartford Railroad is said to be inquiring for 10 switchers.

The Alabama & Vicksburg Railway has ordered three Pacific type locomotives from the Baldwin Locomotive Works.

The Mobile & Ohio Railroad has ordered two Pacific type locomotives from the Baldwin Locomotive Works.

The Cherokee Company has ordered one Shay type locomotive from the Lima Locomotive Works.

The Argentine State Railway has ordered five Mikado type locomotives from the Baldwin Locomotive Works.

The South Manchurian Railway has ordered five Mikado type locomotives from the American Locomotive Company.

The New York Central Railroad is reported to have placed an order for seven switchers with the Lima Locomotive Works.

The Columbia, Nahelan River Company, Carry, Ore., has ordered one Prairie type locomotive from the Baldwin Locomotive Works.

The Columbia, Nahelan River Company has purchased one locomotive from the Baldwin Locomotive Works.

The San Joaquin & Eastern Railroad has ordered one Prairie type locomotive from the Baldwin Locomotive Works.

Freight Cars

The Seaboard Air Line Railway is inquiring for 932, 40-ton flat car bodies.

The New York Central Railroad is reported as contemplating buying 500 sheated box cars for the Rutland Railroad.

The Bangor & Aroostook Railroad is inquiring for 75 steel underframes and superstructures.

The Baltimore & Ohio Railroad has placed an order with the Bethlehem Shipbuilding Company for 1,000, 70-ton gondola cars.

The Northern Pacific Railway is inquiring for 200 ore cars of 75 tons' capacity.

The Lehigh Valley Railroad is reported to be in the market for repairs to 200 gondola cars.

The Norfolk & Western Railway has placed 500, 57½-ton hopper cars for repairs with the Ralston Steel Car Company, and 500 with the Newport News Shipbuilding and Dry Dock Company.

The Western Pacific Railroad has ordered 200 automobile cars from the Standard Tank Car Company.

The Southern Pacific Company has awarded contracts for the construction of cars to the following companies: 2,975 box cars to the Standard Steel Car Company, 500 automobile cars to the Pullman Company, 200 oil tank cars to the General American Tank Car Corporation, 600 drop-bottom gondola cars to the General American Car Company, 450 flat, 250 stock and 500 tight-bottom gondola cars to the Ralston Steel Car Company.

The Western Pacific Railroad is inquiring for 200 ore cars of 70 tons' capacity.

The Interstate Public Service Company, Indianapolis, Ind., has ordered 10 stock cars from the American Car & Foundry Company.

The Western Fruit Express is inquiring for 1,000 refrigerator cars.

The Chicago & Alton Railroad has ordered 250 box cars from the Pullman Company.

The Missouri-Pacific Railroad is reported to have placed 1,000 box cars for repairs with the Sheffield Car and Equipment Company.

The Great Western Railway of Brazil is inquiring for 50 special type freight cars.

The American Steel & Wire Company is inquiring for 20 steel gondola cars.

The Wabash Railway has placed 1,750 box cars with the Western Steel Car & Foundry Company, and 250 gondola cars with the General American Car Company.

The Swift Car Lines are inquiring for 300 steel underframes for refrigerator cars.

The Atlanta & West Point Railroad is inquiring for 100 composite high side gondola cars of 50 tons' capacity.

The Ann Arbor Railroad has placed 250, 40-ton box and 250, 40-ton automobile cars with the Standard Tank Car Company.

Passenger Cars

The Lehigh Valley Railroad has purchased 25 steel underframe milk cars from the American Car & Foundry Company.

The Central of Georgia Railway is inquiring for two partition coaches and four straight coaches.

The Canadian Pacific Railway has ordered 10 steel frames for passenger coaches from the National Steel Car Corporation.

The Missouri-Pacific Railroad is inquiring for three gasoline motor car coaches.

The Great Northern Railway has ordered one gasoline motor rail car from the J. G. Brill Company.

The Sewell Valley Railroad has ordered three gasoline motor rail cars from the J. G. Brill Company.

The Gulf, Mobile & Northern Railroad is in the market for two baggage and mail cars, two partition coaches and two straight coaches.

The New York Central Railroad is reported to have ordered 18 steel coaches from the American Car & Foundry Company, and 18 from the Standard Steel Car Company.

The Rapid Transit Subway Construction Company of New York has ordered 100 motor cars from the American Car & Foundry Company.

The Southern Pacific Company is inquiring for six interurban cars.

The Virginia & Carolina Southern Railroad has ordered one gasoline motor car from the Edwards Railway Motor Car Company.

The Unadilla Valley Railway has purchased one gasoline motor car from the J. G. Brill Company.

The Alabama & Vicksburg Railway has ordered five coaches, two combination passenger and baggage cars and one baggage car from the American Car & Foundry Company.

The Tennessee, Kentucky & Northern Railroad has placed an order for one motor car with the Edwards Railway Motor Car Company to be delivered early this year.

The Pennsylvania Railroad has ordered three gasoline rail cars from the J. G. Brill Company.

The Chicago-Great Western Railroad has ordered two gasoline motor cars and trailers from the Sykes Company.

Buildings and Structures

The Southern Pacific Company is reported to have awarded a contract to Charles A. Fellows, of Los Angeles, Cal., for the construction of a one-story locomotive shop at Los Angeles, Cal.

The Atchison, Topeka & Santa Fe Railway is reported to have completed plans for enlargements of its shops at Emporia, Kans.; a power house, machine shops and other structures will be added.

The New York, Chicago & St. Louis Railroad will construct a one-story machine shop at Conneaut, Ohio, to cost approximately $40,000.

The Texas Pacific Railway, now in the process of reorganization, has prepared plans for new locomotive and car repair shops at Dallas, Tex.

The Louisville & Nashville Railroad will construct a one-story machine shop at Etowah, Tenn.

The Illinois Central Railroad has prepared plans for the construction of a new locomotive shop, enginehouse and oil station at Sioux City, Ia., to cost approximately $500,000.

The Union Pacific Railroad will construct an eight-stall extension to the roundhouse, also the installation of a boiler washing plant at Caliente, Nev., to cost approximately $86,000.

The Pennsylvania Railroad is planning the construction of a one-story car shop at Camden, N. J., to replace a portion destroyed by fire.

The Michigan Central Railroad has prepared plans for a new engine house and repair shop at North Lansing, Mich., with a capacity of about 10 locomotives.

The Wabash Railway plans the construction of a 20-stall roundhouse at St. Thomas, Ont., Canada.

The Central of Georgia Railway plans the reconstruction of a portion of its car shops at Savannah, Ga., recently destroyed by fire.

Items of Personal Interest

F. A. Butler has been appointed Superintendent of Motive Power and Rolling Stock of the Boston & Albany Railroad succeeding **R. D. Smith**, retired from the service at his own request.

E. L. Grimm has been appointed assistant to the general mechanical superintendent of the Northern Pacific Railway with headquarters at St. Paul, Minn.

J. L. Smith has been appointed superintendent of motive power of the Pittsburgh & West Virginian Railway and the West Side Belt Railroad with headquarters at Pittsburgh, Pa., succeeding **H. P. Anderson** resigned.

C. P. Taylor has been appointed electrical engineer of the Norfolk and Western Railway with headquarters at Roanoke, Va., succeeding **C. H. Quinn** who has resigned.

James Matheson has been appointed master mechanic of the Seattle division of the Northern Pacific Railway with headquarters at Seattle, Wash.

L. C. Sprague, superintendent of the Uintah Railway with headquarters at Mach, Colo., has been appointed acting general manager with the same headquarters succeeding **James E. Hood**, deceased.

J. B. Flaherty has been appointed acting general superintendent of the Denver & Salt Lake Railroad with headquarters at Denver, Colo.

R. W. Hunt of the Atchison, Topeka & Santa Fe Coast Lines and the Grand Canyon Railway has been appointed fuel supervisor, with headquarters at Los Angeles, Calif.

J. R. Lancaster has been appointed superintendent of the locomotive shops of the Delaware, Lackawanna & Western Railroad at Scranton, Pa.

G. F. Endicott of the Northern Pacific Railway has been appointed mechanical engineer with headquarters at St. Paul, Minn.

L. N. Reed of the New York, New Haven & Hartford Railroad has been appointed mechanical manager with headquarters at New Haven, Conn., succeeding **H. C. Oviatt**, resigned.

J. A. Moran, assistant division superintendent on the St. Louis, San Francisco Railway with headquarters at Neodesha, Kans., has been promoted to superintendent of the River division with headquarters at Chaffee, Mo., succeeding **F. G. Faulkner**, who has been promoted.

O. C. Hibbs has been appointed superintendent of the Brookfield division of the Chicago, Burlington & Quincy Railroad with headquarters at Brookfield, Mo.

Silas Zwight has been appointed general mechanical superintendent of the Northern Pacific Railway to succeed **H. M. Curry** who has retired after forty-three years of continuous service with the Northern Pacific.

Thomas R. Williams has been appointed assistant to the Master Car Builder of the Northern Pacific Railway with headquarters at St. Paul, Minn.

Frank Roehr of the Southern Pacific Co., has been appointed master car repairer of the San Joaquin division with headquarters at Bakersfield, Calif., succeeding **M. H. Warren**, who has retired.

J. M. Pierce, master mechanic on the Kansas City Southern Railway with headquarters at Heavener, Okla., has been transferred to the Southern division with headquarters at Shreveport, La., succeeding **G. W. Lillie**, who has resigned.

T. J. Cutler, of the Northern Pacific Railway, has been appointed mechanical superintendent of the lines east of Paradise, Mont., with headquarters at St. Paul, Minn.

R. A. Greene, supervisor of fuel and lubrication of the Chicago & Alton Railroad, with headquarters at Bloomington, Ill., has resigned to enter the service of the Galena-Signal Oil Company with headquarters at Chicago, Ill.

W. P. Hayes, division engineer of the Missouri Pacific Railroad with headquarters at Monroe, La., has been promoted to train-master with same headquarters.

B. B. Milner, of the Missouri-Kansas-Texas Railroad has been appointed mechanical engineer with headquarters at Parsons, Kans.

F. T. Quinlan of the New York, New Haven & Hartford Railroad has been appointed engineer of tests.

H. C. Caswell of the Buffalo division of the Delaware, Lackawanna & Western Railroad, with headquarters at East Buffalo, New York, succeeding **F. C. Pickard**, resigned.

J. E. Hutchinson, general manager of the St. Louis-San Francisco Railway, with headquarters at Springfield, Mo., has been promoted to vice-president in charge of operation to fill the vacancy created by the retirement of **T. A. Hamilton**.

C. C. Hamilton has been appointed master mechanic of the Canton Railroad with headquarters at Baltimore, Md.

William L. Bean, of the New York, New Haven & Hartford Railroad, has been appointed assistant mechanical manager, and **F. E. Ballda** has been appointed assistant to the mechanical manager.

M. A. Quinn, of the Delaware, Lackawanna & Western Railroad, has been appointed master mechanic of the Syracuse & Utica division with headquarters at Binghamton, New York.

W. G. Wise has been appointed traveling engineer of the Minnesota division of the Illinois Central with headquarters at Dubuque, Iowa, vice **W. L. Ickes**, retired on pension.

Supply Trade Notes

The Union Asbestos & Rubber Company of Chicago announces the appointment of **W. G. Cook** as eastern representative with headquarters at Philadelphia, Pa. Mr. Cook was formerly connected with the Garlock Packing Company with headquarters at Chicago.

Franklin Railway Supply Company, Inc., New York, has announced the appointment of **J. G. Aye**, formerly general foreman of the Southern Pacific Co., with headquarters at Fresno, Calif., as service engineer.

The Lehon Company, manufacturers of the Mule-Hide Roofing, announces the removal of its New York office to 95 Liberty street, New York City.

Charles E. Lee, formerly general superintendent of the Boston & Maine, who has for several years been making special transportation studies and reports for various interests in different sections, has established headquarters at 30 Church street, New York City. Associated with Mr. Lee are **C. H.** Garber, consulting railroad engineer of Omaha, a specialist in valuation, construction and maintenance reports, and **James R. Hendry**, an expert in motor truck transportation.

The Standard Steel Car Co. recently elected **J. F. Drake** president, and **J. M. Hensen**, former president, was made chairman of the board of directors. **P. J. Jenks**, former assistant to the president, has been made vice-president, succeeding J. F. Drake.

The Q. & C. Company, New York City, announces that it has acquired the exclusive United States rights for the manufacture and sale of the unlimited travel type roller side bearing under any and all patents granted to **E. A. Laughlin**, Oregon, Ill., and previously sold by the **Standard Coupler Company**.

The MacRae's Blue Book of Chicago, has taken over the **Hendrick Commercial Register of New York**, owned by the Kelly Publishing Company, London, England. Both will be continued in their present form.

Harvey W. Cutshall, formerly with **Mudge & Company**, has been appointed sales manager of the **Northwestern Motor Co.**, of Eau Claire, Wis., in charge of Chicago and St. Louis territory with headquarters in the McCormick Building, Chicago.

J. F. Farrell, general manager and a director of the **Nathan Manufacturing Company**, has been elected vice-president, **Alfred Nathan, Jr.**, secretary, has been elected treasurer and **Edwin F. Wallace** has been elected secretary, all with the same headquarters, New York City.

The American Locomotive Company will build a one-story addition to its shops at Schenectady, New York.

The Bucyrus Company, South Milwaukee, Wis., is preparing plans for an addition to its plant at Evansville, Ind.

The National Malleable Castings Company, Cleveland, Ohio, will change its corporate name in the near future, to the **National Malleable & Steel Castings Co.** The corporation now has shops in operation at Cleveland, Ohio, Sharon, Pa., Toledo, Ohio, Indianapolis, Ind., East St. Louis, Ill., Chicago and Melrose Park near Chicago. There will be no change in the officers or personnel of the corporation and the change in name is to be made to cover the scope of its steel castings production.

The Crane Company, Chicago, is preparing plans for a one-story factory branch building at South Bend, Ind.

The Baldwin Locomotive Works, Philadelphia, is perfecting plans for the removal of its engine tender shop to the plant at Eddystone, Pa., where the department will be considerably increased. The other shops and mechanical departments will be retained at Philadelphia. The new Eddystone shop will cost about $600,000.

J. R. Sexton, railway sales manager of the **H. H. Robertson Company** with headquarters at Chicago, has also been appointed district manager with the same headquarters, succeeding **H. F. Hackedorn**, deceased.

The Talmadge Manufacturing Co., Cleveland, Ohio, announces the election of **Frank C. Pickard** as vice-president of the company, effective December 1, 1923.

The Bethlehem Shipbuilding Corp., Ltd., has removed its city sales offices to 1000 Matson Building, 215 Market street, San Francisco, Calif.

The Pfaudler Company, Rochester, N. Y., makers of glass-lined steel milk tank cars, has appointed H. A. Stuart, manager of the newly created milk transportation division with headquarters at Rochester, N. Y. This company has inaugurated a system of leasing so that the dairyman is not obliged to purchase the glass-lined milk tank car used in transporting milk in bulk but may lease it for a period of time at a fixed rental, and at the end of this period either purchase the car outright or renew the lease.

The Truscon Steel Company, Youngstown, Ohio, has authorized the expenditure of $400,000 for the extension of its plant in Youngstown. The buildings will cover two and one-half acres and will increase the floor space to 16 acres. Work will be finished by May 1.

L. G. Plant, a member of the editorial staff of the **Railway Review**, has resigned to accept an appointment as assistant to the president of the National Boiler Washing Co., Railway Exchange Building, Chicago. Mr. Plant was born at Minneapolis, Minn., in 1885, and was first employed by the Baldwin Locomotive Works as a special apprentice and as a boiler maker's apprentice on the Southern Railway. He studied at the University of Virginia and at Stevens Institute of Technology, receiving from the latter the degree of mechanical engineer, in 1909. He then entered the employ of the Southern Pacific Lines as a student of operation. Later he was employed as a mechanical engineer on a subsidiary of the Southern Pacific in charge of equipping the railroad for the use of fuel oil, and in 1913 was appointed superintendent of fuel service for the Southern Pacific Lines in Texas and Louisiana. In 1914 he was appointed fuel engineer on the Seaboard Air Line Railway which position he held until 1918. Shortly after the division of finance and purchases of the United States Railroad Administration was organized at Washington, he was made progress engineer and chief clerk to the manager of the procurement section. Mr. Plant's appointment with the National Boiler Washing Co. will identify him with the broad plans which this company has recently undertaken for the improvement of locomotive terminals with a view to enlarging the productive output of locomotives and the arrangements for financing these improvements by the National Boiler Washing Co. upon a locomotive terminal equipment trust basis similar in principle to the manner in which the purchase of locomotives and cars is ordinarily financed.

Obituary

J. H. Setchel, formerly secretary and president of the American Railway Master Mechanic's Association and later sales manager of Jerome & Elliott, Chicago, Ill., died on December 13 at Cuba, N. Y. He was born in 1835, at South Brainbridge, Chenango County, New York, and in early life entered railroad service with the Galena & Chicago Union Railroad in its roundhouse. When the Civil War broke out he was a locomotive engineer on the Louisville & Nashville. During the first year of the war he was a foreman at Nashville, Tenn., and from 1862 to 1868, he was a locomotive engineer on the Little Miami Railroad. During the latter year he was promoted to assistant master mechanic in charge of the shops at Columbus, Ohio, which position he held until 1873, when he became superintendent of the Kentucky Central. From 1874 to 1885 he was general master mechanic of the Ohio & Mississippi and in the latter year he resigned to become superintendent of the Brooks Locomotive Works. Later he entered the employ of the Pittsburgh Locomotive Works as general traveling agent. In November, 1902, he was appointed western representative and traveling agent for the American Locomotive Company with headquarters at Chicago, which position he held until October 1, 1903, when he became general sales manager for Jerome & Elliott. He was elected secretary of the American Railway Master Mechanic's Association at its fourth annual meeting, which position he held for 18 years when he was elected president for two years.

Stephen C. Mason, secretary of the McConway & Torley Co., of Pittsburgh, and a past president of the National Association of Manufacturers, died at his home in Pittsburgh, December 12, due to heart failure. Mr. Mason was born at Fairlee, Vt., in 1861, entered the employ of the Connecticut & Passumpic Railroad in 1880, remaining with this road until 1888. In this year he went to Washington, D. C., as an advisor to the Interstate Commerce Commission, later becoming assistant statistician. He remained with the commission for eight years, the last three years of which time he was in direct charge of the statistical division and the compilation of the statistical reports published by the commission. In 1896 he became associated with the McConway & Torley Co. of Pittsburgh, Pa., and later became secretary and a director of that company. For a number of years Mr. Mason served as vice-president of the National Association of Manufacturers, and from 1918 to 1921, served as president of that association. He also served as vice-president of the Steel Founders' Society of America, executive member of the Railway Business Association, member of the National Industrial Conference Board, member of the finance committee of the Railway Club of Pittsburgh, and member of the Chamber of Commerce of Pittsburgh.

Stephen C. Mason

Lord Thomas G. Shaughnessy, chairman of the board of directors of the Canadian Pacific Railway, and former president of that road, died at his home in Montreal, December 10, from heart failure. Lord Shaughnessy was born at Milwaukee, Wis., in 1853, and entered railway service in 1869 as a clerk in the purchasing department of the Chicago, Milwaukee & St. Paul Railway. In 1879 he was appointed general storekeeper for this road, and remained in that capacity until 1882, at which time he entered the service of the Canadian Pacific Railway, as general purchasing agent. In 1884 he was appointed assistant to the general manager, and a year later was made assistant general manager. In 1889 he was made assistant to the president, and two years later was made vice-president and director. He continued in that capacity until 1899 when he was elected president of the road. In 1918 he retired from the presidency and was made chairman of the board of directors.

William Forsyth, formerly superintendent of motive power of the Northern Pacific, died at Chestnut Hill, Pa., on December 3. Mr. Forsyth was born on July 2, 1852, at Northumberland, Pa., and attended the Polytechnic College of Pennsylvania at Philadelphia from 1868 to 1870. He entered railway service in the latter year as a machinist's apprentice on the Philadelphia & Reading. In 1874 he was employed by the Altoona Iron Company, at Altoona, Pa., and a year later he entered the test department of the Pennsylvania at Altoona, where he remained until 1881 when he was appointed assistant master mechanic of the Pittsburgh, Fort Wayne & Chicago, with headquarters at Fort Wayne, Ind. In 1882, he was appointed mechanical engineer of the Chicago, Burlington & Quincy, and in 1898 he was appointed superintendent of motive power of the Northern Pacific. In 1900, Mr. Forsyth was appointed mechanical engineer for the Pennsylvania Coal Company at Scranton, Pa., and a year later, was appointed associate professor of locomotive and car design at Purdue University. He was appointed mechanical engineering editor of the Railway Age in 1903 and upon the consolidation of that paper with the Railroad Gazette, was appointed associate editor (mechanical) of the Railway Age Gazette. He continued in this capacity until 1911, when he retired.

New Publications

Books, Bulletins, Catalogues, Etc.

Proceedings of the American Society for Testing Materials, Vol. 23 (1923) has been issued and is in two parts.

Part I (1066 pp.) contains the annual reports of 32 of the standing committees of the society, together with the discussion thereon at the annual meeting, and 105 tentative standards which have been revised or are published for the first time; the annual address of the President and the annual report of the Executive Committee.

Part II (683 pp.) contains 50 technical papers with discussions. The technical papers contain valuable information on results of investigations by experts in the field of engineering materials and the reports of the committees cover Ferrous and Non-Ferrous Metals, Cement, Ceramics, Concrete, Gypsum, Lime, Preservation Coatings, Petroleum Products, Road Materials, Coal and Coke, Water Proofing Materials, Electric Insulating Materials, Shipping Containers, Rubber Products, Textile Materials, Methods of Testing, and Nomenclature and Definitions.

Copies may be purchased through C. L. Warwick, Secretary-Treasurer of the Society, Engineers' Club Building, Philadelphia, Pa.

Manual of Instruction for Welding Operators—This manual contains a complete set of outlines of lessons, exercises and examination for the training of oxy-acetylene welders and electric arc welders. In the outline of lessons a great deal of care has been exercised to provide a logical development of welding instruction, and to give reading references which will enable the instructor and student to secure full information on every topic in the outline. The exercises in each course start with an exercise in setting up the apparatus for welding, and carries the student through the more general operations, then provides special exercises typical of the work done in some of the more important industries which are large users of the welding processes. In the case of each exercise the objective is clearly stated and auxiliary information is supplied covering the important points which might be overlooked by the student in his course of reading. Lessons and exercises are supplemented by lists of general and special examination questions. These questions may be made to serve a threefold purpose. The instructor can use them to determine how much the student has gained from his course of instruction; the employer can use them to determine the ability of the applicant for a welding position, and the welder himself can use them as a check on his own knowledge of the work which he is doing. The manual contains two pages of color charts, one of them illustrating the appearance of metal at varying temperatures and the other showing the proper adjustment of the oxy-acetylene flame. There are also two pages of illustrations showing step by step how to assemble the oxy-acetylene apparatus and get it ready for operation. This little booklet has been prepared for the use of welding instructors, welding foremen, welding supervisors and welding students. It will be sent free to interested parties by THE WELDING ENGINEER, 608 S. Dearborn St., Chicago, Ill.

The Westinghouse Electric & Manufacturing Company has issued three descriptive leaflets dealing with railway motors and electric locomotives.

The first, Leaflet Number 20,124, gives specifications for the Class B-1, 50 Ton Locomotive, including ratings of hourly continuous and maximum capacity. The particular application of the locomotive is described and the details of its construction are enumerated. Performance curves of the locomotive under various conditions and a dimensional drawing and list of weights complete the information included in the leaflet.

The second, Leaflet Number 20,125, contains specifications for the No. 562 Railway Motor. On the first page are hourly and continuous capacity ratings, as well as a descriptive paragraph of the application of the motor and a table indicating the performance of a 50 ton locomotive equipped with four of these motors. Construction details take up the second page, while on the third are performance curves of the motor. On the last page an outline drawing gives the details and dimensions of the motor. A list of types of the 562 motor and a list of approximate weights conclude the leaflet.

The third, Leaflet Number 20,047, gives specifications for the Number 557 Railway motor. This contains essentially the same information regarding the No. 557 motor as leaflet No. 20,125 regarding the No. 562 motor. The only difference is that the table on the first page of this publication is one to determine the suitability of the motor for a desired schedule.

Mundy's Earning Power of Railroads. The eighteenth annual issue of this valuable handbook which is compiled and edited by Floyd W. Mundy of Jas. H. Olyphant & Co., 61 Broadway, New York, has recently been issued. It presents important statistics and other facts relating to the earning power and to the securities of railroads, arranged in convenient form for ready reference. The statistics are given for practically all the important railroads in the United States, with a few others, the securities of which are known, in a greater or less degree to American Investors.

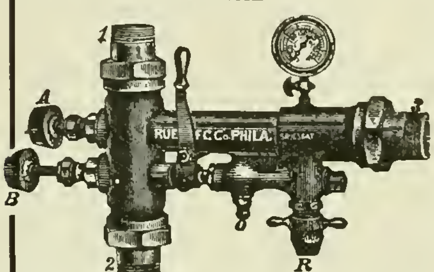
The Introductory Chapter explains in a general way the fundamental principle which must be applied by the investor to inform himself as to the value of the stocks or bonds of any railroad.

The Tables, which give vital statistics regarding earnings, mileage, capitalization, tonnage, etc., are designed to present the statistics in such form as to permit easy comparison.

The Notes give information as to dividends and such other information about the railroads' capitalization, investments, physical and financial condition, etc., as appears to be of direct interest to the investor.

The official annual railroad reports have been used almost exclusively in the preparation of this book.

The method of presentation is, we believe, such as will readily commend itself to investors and others interested in the securities of railroads.



Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

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Decapod Type Locomotive for the Gulf, Mobile and Northern Railroad

A Powerful Unit With Moderate Axle Load—Details Interchange Where Practical With the Mikado Type on This Road

With an increasing freight traffic and the consequent necessity of handling heavier train loads, locomotives with five pairs of coupled driving wheels are being placed in service on many railroads throughout the country. Two wheel arrangements are available for road service, the Decaped (2-10-0) and the Santa Fe (2-10-2). The latter is necessarily the heavier in proportion to tractive force developed, but it has the advantage of higher relative boiler power, and this is important where service conditions are unusually severe, or where the fuel used is of poor quality. The Decapod type, however, with approximately 90 per cent of its total weight on driving wheels, is a more efficient freight hauler for heavy drag service where moderate speeds will suffice. In this respect is compares with the Consolidation (2-8-0) type, while it develops, with the same axle loading, about 25 per cent greater tractive force.

The first locomotives of the Decapod type were two in number, and were built in 1867 by the Norris Locomotive Works, of Philadelphia, for the Lehigh Valley Railroad, to specifications prepared by Alexander Mitchell, Master Mechanic of the Mahanoy Division of that road. These locomotives were a direct outgrowth of the locomotive "Consolidation," built by The Baldwin Locomotive Works in 1866 to Mr. Mitchell's specification. They were subsequently modified, the rear pair of drivers being replaced by a two-wheeled truck, thus giving the 2-8-2 wheel arrangement. This, however, did not convert them to the Mikado type as known today, as they had narrow fireboxes placed between the rear drivers.

The first Decapod type locomotives built by The Baldwin Locomotive Works were two in number, completed in 1881 for the Mexican National Construction Company. This was a narrow gauge design. In 1885, the Dom Pedro Segundo Railway of Brazil received a broad (5′ — 3″) gauge Baldwin locomotive of this type, which weighed 141,000 pounds and attracted much attention at the time because of its large size. In the following year, two Decapods of approximately the same weight were built for the Northern Pacific, and the type was thus reintroduced in this country. The most extensive user of this type is now the Pennsylvania System, which several years ago had a large number of these engines built at Altoona, and during 1922-23 received 475 from The Baldwin Locomotive Works. These have been distributed over the System for use in the heaviest class of freight service.

Decapod Type Locomotive for the Gulf, Mobile and Northern Railroad, Built by Baldwin Locomotive Works

An interesting application of the Decapod type is found on the Gulf, Mobile and Northern Railroad, whose main line extends from Mobile, Alabama, to Jackson, Tenn., a distance of 409 miles. This road has recently placed five Baldwin Decapods in service in the new Albany District, at the northern end of the line. The type was selected, in this case, in order to obtain a powerful unit with a moderate load per axle. The locomotives exert a tractive force of 60,000 pounds and can safely be used on rails weighing 75 pounds and over per yard. They are operating on curves of 16 degrees and grades of 1½ per cent. and are handled on 80-foot turn tables. They are equipped with superheaters, Ragonnet type "B" power reverse gears, and coal pushers on the tenders, and are so designed that mechanical stokers can subsequently be applied, if necessary. The details interchange where practicable, with those of a number of Mikado type locomotives built for the road in 1921.

The new Decapods have straight top boilers with wide fireboxes placed above the rear drivers, and tubes 17 feet 6 inches long. A brick arch is used, and is supported on four tubes. The superheater is composed of 36 elements, and the superheating surface is 22½ per cent of the water evaporating surface.

Machinery details include steel piston heads, alligator guides and crossheads, and a simple design of Walschaerts valve gear, operating 14-inch piston valves. These have a steam lap of 1 inch and no exhaust clearance, and are set with a maximum travel of 6¼ inches and a lead of 3/16 inch. The cylinders are equipped with automatic drifting valves.

The running gear details are of most substantial construction, and are designed throughout for severe service. The equalization system divides between the third and fourth pairs of drivers. The main frames are 6 inches wide, and are spaced 42 inches between centers. To facilitate curving, the middle (main) drivers have plain tires. The tender is carried on two equalized pedestal trucks, and the frame is built up, with 12-inch longitudinal channels and cast steel bumpers. The tank is of the water bottom type, with capacity for 8,500 gallons of water and 18 tons of coal.

These locomotives are equipped with steam heat, so that they can, in cases of emergency, be used in passenger service.

Further particulars of this interesting design are given in the table of dimensions.

Decapod Type Locomotive, Gulf Mobile & Northern Railroad

Gauge		4 ft. 8½ in.
Cylinders		25 in. by 30 in.
Valves—Piston		14 in. diam.
Tractive force		60,000 lb.
Service		Freight
Boiler		
Type		Straight top
Diameter		76 in.
Working pressure		215 lb.
Fuel		Soft coal
Firebox		
Material		Steel
Staying		Radial
Length		108⅛ in.
Width		86¼ in.
Depth, front		74½ in.
Depth, back		60½ in.
Tubes		
Diameter	5⅜ in.	2 in.
Number	36	217
Length	17 ft. 6 in.	17 ft 6 in.
Heating Surface		
Firebox		203 sq. ft.
Tubes		2,862 sq. ft.
Firebrick tubes		42 sq. ft.
Total		3,091 sq. ft.
Superheater		693 sq. ft.
Grate area		64.7 sq. ft.
Driving Wheels		
Diameter, outside		57 in.
Diameter, center		50 in.
Journals, main		11 in. by 12 in.
Journals, others		9 in. by 12 in.
Engine Truck Wheels		
Diameter, front		34 in.
Journals		6 in. by 12 in.
Wheel Base		
Driving		20 ft. 0 in.
Rigid		20 ft. 0 in.
Total engine		28 ft. 11 in.
Total engine and tender		65 ft. 1 in.
Weight (working order)		
On driving wheels		225,500 lb.
On truck		26,600 lb.
Total engine		252,100 lb.
Total engine and tender		434,500 lb.
Tender		
Wheels, number		8
Wheels, diameter		33 in.
Journals		6 by 11 in.
Tank capacity		8,500 U. S. gal.
Fuel capacity		18 tons

Equipped with superheater, power reverse, and air brake on all driving and tender wheels, with two 9½-in. pumps.

Comparative Cost of Equipment in 1907 and 1923

The Bureau of Railway Statistics in Chicago has compiled tables from the records of the Interstate Commerce Commission showing the amount paid for new rolling stock and other rail equipment in 1907, compared with the prices for the same material and equipment in 1923.

The records show the following:

	1907	1923
Heavy freight locomotives, each	$16,243.00	$53,550.00
Passenger locomotives, each	16,057.00	66,200.00
Switching locomotives, each	11,857.00	39,000.00
Passenger coaches, each	7,330.00	28,900.00
Baggage cars, each	4,820.00	21,000.00
Freight cars, each....... $700 to	825.00	2,301.00
Rails, ton	28.00	43.00
Angle bars, each	0.317	1.99
Track bolts, cwt	2.45	4.30
Track spikes, cwt	1.90	3.15
Handcar wheels, each	2.70	6.25
Common wire nails, cwt	2.00	3.14

Capacity of Belgian Locomotive Works

The 17 principal locomotive builders in Belgium are capable of producing an average of slightly over one locomotive per week per factory, according to recent estimates. This figure, however, must be regarded as purely abstract, in view of the fact that since the armistice no Belgian locomotive plant has worked at capacity; under present conditions even the Cockerill Works would be doing well to turn out regularly 25 locomotives a year. No construction plant has a fixed staff for locomotive manufacture, help being usually transferred from other branches when a locomotive order is taken. The fact that capacity, from a practical standpoint, is considerably below the estimate is amply demonstrated by the fact that of 102 locomotives ordered by the railroad administration in February, 1920, from various Belgian plants, 22 were still unfinished on April 1, 1923.

Pennsylvania Builds Three New Electric Locomotives

Now Under Construction at the Altoona Shops Preparatory to Establishing a Standard Electric Locomotive for Their System

By T. C. WURTS, General Engineer, Western Electric & Manufacturing Co.

Some idea of the foresight and study given large problems by some of the leading corporations of this country can be realized by the fact that before the New York Terminal of the Pennsylvania Railroad between Manhattan Transfer and New York City was placed in operation, experimental work preceded the adoption of the electric locomotives now in service. During this experimental period four locomotives were built, and a continuous joint vigorous study of these locomotives was made by the Railroad Company and the Westinghouse Electric & Manufacturing Company to determine the best possible type of locomotive to meet the requirements of the service. The results fully justified the time and expense of this extensive preparatory work.

With the prospect of extensive main line electrification in the near future, and with the probability of the electrification of the Altoona grade before many years, the Pennsylvania Railroad, with the same foresight that characterized their study of a locomotive type for the New York Terminal, built a split-phase locomotive of 4000 hp. continuous rating, known as the "FF-1" locomotive, and placed it in service in the spring of 1917.

The war and government control of the railways, combined with other causes, delayed somewhat the test of this locomotive, which is now in regular freight service between Philadelphia and Paoli.

In the meantime, however, the Railroad Company's engineering organization has been busy designing another type of locomotive for freight service. As an experiment, they are planning to equip the same locomotive that has been designed primarily for freight service, to operate in high speed passenger service by simply changing the gear ratio.

At the Railroad Company's Altoona Shops there are now being built three powerful locomotives, all of the same type. One of these is to be used for freight service under the single phase A. C. trolley, while the other two are to be given extensive tests to determine their adaptability for passnger service, after which it is proposed to use them as D. C. locomotives on the New York Tunnel and Terminal Division of the Railroad.

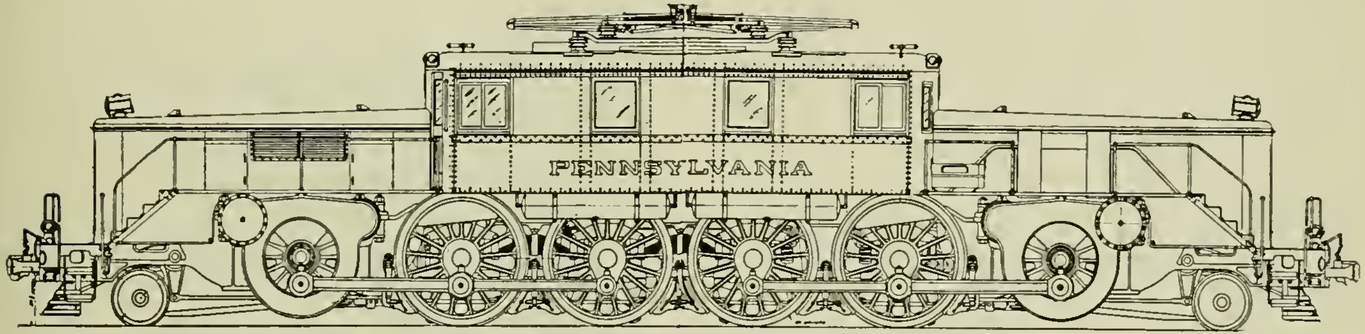
Each locomotive will weigh approximately four hundred thousand pounds, and will be equipped with four single phase commutator type motors. These motors have a continuous rating on single phase of 760 hp., giving a total locomotive rating of 3040 hp.

The locomotives have a 2-8-2 wheel arrangement with the so-called "steeple" type cab construction. The motors are arranged two per jack shaft, and are mounted outside of, and at either end of the driving wheel base. Each jack shaft serves two pairs of drivers. The connection between the motors and the jack shaft is by means of pinions and flexible gears.

The single phase freight locomotive will have a gear ratio of 30:118 and a maximum speed of thirty-five miles per hour. The two locomotives that are being arranged for D. C. passenger service over the New York Tunnel and Terminal Division will have a gear ratio of 50:98, permitting a maximum speed of seventy miles per hour.

Although two of these locomotives are being laid out for D. C. operation, while the third is to operate under an A. C. trolley, the motors and all other parts possible are being made identical. The space required for the transformer on the A. C. locomotive is devoted to accelerating resistance on the D. C. locomotive. The pantagraph on the A. C. locomotive gives place to the third rail shoe on the D. C. locomotive, etc.

Side rods will be utilized for the transmission of power from the jack shaft to drivers. Flexibility between the motor armature and the running gear will be provided by means of springs set in the gear center, and flexible pinions in one of each pair of motors geared to their common jack shaft. These springs in the gear center and in the pinion have been especially devised by the Westinghouse Electric & Manufacturing Company. They are of the leaf type, and are inserted into their pockets without any initial tension, and are so designed that they will be active throughout the operating range of the locomotives. Throughout the design of these locomotives, the underlying principal adhered to has been that of extreme simplicity. A brief description of both the A. C. and D. C. locomotives may be of interest.

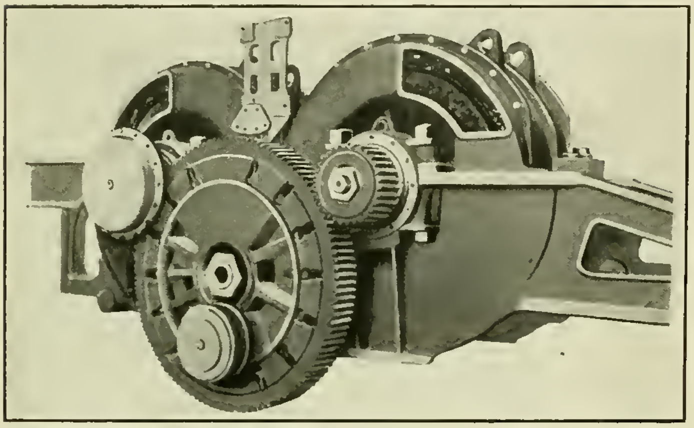


New 200-Ton Single-Phase Road Locomotive for Preferential Freight Service for the Pennsylvania Railroad

A. C. Freight Locomotive

Consideration will first be given to the A. C. freight locomotive, since it was the requirements of this locomotive that primarily determined the characteristics of these locomotives as a type.

The outstanding feature of this locomotive is the traction motor, which has the largest capacity possible under the limitations prescribed by the Pennsylvania Railroad Company. In this connection it should be noted that this motor has the greatest capacity of any single phase commutator type traction motor that has ever been built in this country. Some idea of its size can be gained from the following figures. The outside diameter of the frame is seventy-six inches, while the motor is forty-three and three-quarters inches long. The main frame of the locomotive is so designed and machined that it forms a cradle into which the motor is inserted, thus making the latter an integral part of the locomotive main frame. The motor bearings are carried on the side frames of the locomotives, and are entirely separate from the main frame of the motor itself, but are integral with the motor cradle. In order to maintain the high rating previously mentioned, forced ventilation has been necessary, air being drawn through the motors instead of blowing it through



Two of the Large Single Phase Motors Mounted in Cradle, Showing the Springs in the Gear Center

as has been the usual practice with forced ventilation.

Another interesting and novel feature of this locomotive is the use of an oil insulated, forced cooled transformer. The tank of this transformer is built into the locomotive, but it is entirely separate from the cab structure. Its base rests on pads on the locomotive main frame, while the top is formed by a portion of the cab roof, but at no point is it rigidly connected to the cab structure. The sides of this tank are formed from a single sheet of steel, with a vertical seam joined by a double row of rivets. The bottom of the tank which is an integral cup-shaped piece is set into the side sheets and riveted into place.

The transformer oil will be cooled by being pumped through a forced ventilated radiator. A single motor is provided to drive both the oil pump and the blower which provides the ventilating air.

The locomotive roof is constructed so that the removal of the transformer core from the locomotive can be accomplished by simply removing that portion of the roof directly over the transformer.

Two motor driven blower sets are provided, one for each pair of traction motors. The motors driving these sets and the motor driving the oil pump and blower mentioned above are identical with the single exception of the shaft extension. This feature lends itself to simplicity and ease of maintenance.

The control of the traction motors again emphasizes simplicity. The apparatus provided consists only of a master controller, a reverser, the necessary unit switches for a notch-by-notch voltage increase to the normal voltage of the traction motors, preventive coils, and the minimum number of relays consistent with safety. In addition to this apparatus there is a small motor generator set used for charging the storage battery which furnishes the energy for the control apparatus and lights. The braker system is of the standard locomotive type. The brake lever system is designed for clasp brakes, giving 100 per cent braking power at the driving wheel. The above constitutes practically all of this very simple locomotive.

The locomotive capacity is as follows:

	Continuous	Hourly
Tractive Effort (Lb.)............	50,000	62,000
Speed (M. P. H.)................	23	19.75
Maximum T. E. (Lb. at 33⅓% adhesion)		100,000
Maximum Speed (M. P. H.).......		35

This means that the locomotive is capable of hauling 2,370 adjusted tons up the western slope of the Altoona grade at an approximate speed of 24 miles per hour.

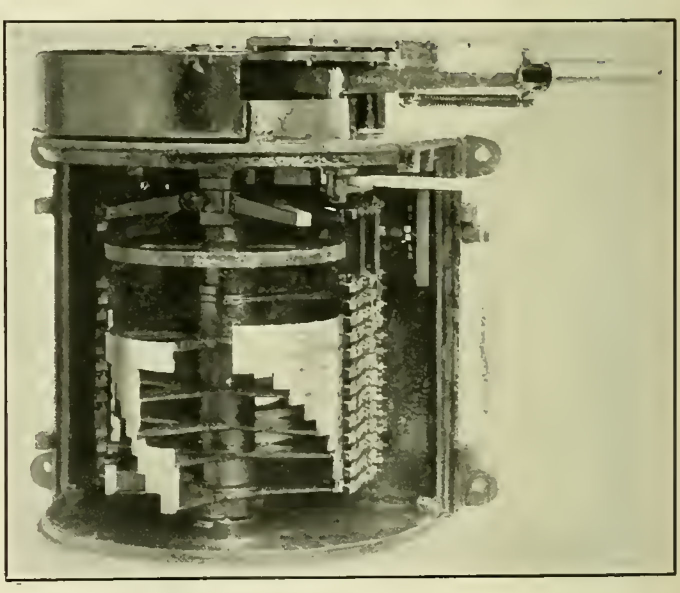
D. C. Locomotives

As indicated earlier in this article, the passenger locomotives are of the same fundamental design as the freight locomotives just described, and are intended for operation on the New York Tunnel and Terminal Division.

The traction motors are identical to those used on the freight locomotive, and with the gearing provided, the locomotive is capable of handling the largest Pullman train entering or leaving the New York Terminal.

The blower sets are also a duplicate of those on the A. C. locomotive. A number of parts on the electrical equipment required for D. C. operation which cannot be made duplicate of the parts on the A. C. engine have been made duplicate of the parts on the present Tunnel and Terminal locomotives. Among these parts may be mentioned the third rail shoes, resistance grids, etc. This will aid in the ease of maintenance of the locomotives.

Mention has already been made of the fact that the motors for these locomotives are in capacity the largest



The Master Controller for the D. C. Locomotive

single phase traction motors in this country. The D. C. locomotives have the additional distinction of being equipped with the largest unit switches in existence. These switches are of the standard Westinghouse electro-pneumatic type, and have a continuous capacity of three thousand amperes. The arc rupturing capacity of these switches is many times this amount on a 750 volt circuit. A total of twenty-three switches is required on each locomotive to adequately handle the motor circuits.

These locomotives will be completed and placed in service early this year, at which time it is proposed to make extensive tests to determine the practicability of this type of locomotive both for high speed passenger and for freight service. If the expectations of the Railroad officials are fulfilled, a tremendous advance will have been accomplished in electric locomotive design by this adaptation of one locomotive to both freight and passenger service.

Some Recent Notable Locomotives

By Mr. James Partington, Estimating Engineer, American Locomotive Company

The locomotives of today are designed and built to meet the special requirements of the service for which they are intended to a greater degree than ever before. These requirements become more and more exacting as the margin between gross and net operating expenses become smaller. During the past decade this margin has shrunk very seriously on every railroad in the United States. Hence the requirements today for motive power efficiency are more exacting than at any previous time in the history of the railroads. Therefore our up-to-date locomotives must in the service for which they are designed be capable of handling the largest tonnage that road conditions will justify; produce and deliver maximum drawbar horse-power at minimum cost and be of a design which will insure minimum maintenance for the service rendered.

To meet these requirements it is necessary that the physical condition of the road be carefully studied, the length of runs for the greatest economy in operation determined, all fuel saving devices carefully considered and incorporated if definite advantage is evident and that the shop facilities for maintenance and repairs be not seriously over-taxed. In accordance with this brief outline I will in a very general way set forth the characteristics and performances of several recent designs.

The Union Pacific R. R. Co. had been operating its heavy passenger trains in the mountainous districts of that road with Mikado type locomotives. Wishing to improve their running time and have a greater margin of reserve power they designed a Mountain type locomotive for this service. Co-operating with the engineers of the Railroad Company the American Locomotive Company built a sample locomotive which was designated as Road Number 7000. On account of road conditions it was essential that the total weight in working order should not exceed 345,000 lbs. It was necessary at the same time to secure the largest possible boiler and cylinder capacities within this limit of weight.

While the rated capacity for cylinders 29 x 38 ins., and 200 lbs. steam pressure is 3030 horse-power, this locomotive has developed in actual road service an indicated horse-power of 3500—one horse-power for every 98½ pounds of engine weight.

Fifty-five of these locomotives are now in service. They are making the run between Cheyenne, Wyoming, and Ogden, Utah, without change of engines handling trains of 13 and 14 all steel cars. The distance is 484 miles with grades as high as 1.55 per cent westbound and 1.14 per cent eastbound. An average speed of 37 miles per hour is maintained.

The boiler is of the conical connection type with a liberal combustion chamber, 239 2¼-in. tubes spaced ¾-in. apart and 48 5½-in. superheater flues. The distance over tube sheets is 22 feet.

The engine is stoker fired with a good grade of bituminous coal.

The grate is 126 inches long and 96 inches wide, having an area of 84 square feet.

The firebox crown and sides and the combustion chamber are made of one sheet eliminating side seams or a weld across the crown at the junction of the combustion chamber. Compared with the maximum cylinder horse-power the boiler has a rated efficiency of 95 per cent and the grate an efficiency factor of 102 per cent.

The driving wheels are 73 inches outside diameter. The centers are of special cast steel with the sections made as light as possible, maintaining proper factors of safety, to keep down the weight. Special steels were used liberally throughout the running gear of the engine—the main and side rods, piston rods, driving and trailing axles and crank pins are of Carbon Vanadium steel. At 60 miles per hour the dynamic augment is only 27 per cent of the weight on drivers and at 73 miles per hour only 39 per cent. The steam distribution is controlled by the Young valve gear and the Alco power reverse gear.

The engine presents a clean cut outline in keeping with its other good points. Special attention was given to avoiding outside piping above the running boards.

The tender which is of Union Pacific standard design provides probably the greatest coal and water capacity for any passenger engines in service, i.e., 20 tons of coal and 12,000 gallons of water.

A number of other roads have put mountain type engines, which closely approximate the Union Pacific design, into service recently showing that this type is steadily gaining in favor for heavy passenger service. We believe this type of locomotive will require less maintenance than the Mikado type if the same or equal service is rendered.

The Most Powerful Ten-Wheel Locomotive

The weight of passenger trains in suburban and local service has become so great on many railroads that it is a common occurrence to see these trains being hauled by Pacific type locomotives of large capacity.

Believing that this service can be more economically performed by properly proportioned ten-wheel type locomotives the Pennsylvania R. R. Co. has recently built and put in service forty (40) ten-wheel engines which I believe are the heaviest and most powerful in existence. These were fully described in the November, 1923, issue of Railway and Locomotive Engineering.

These locomotives have a tractive power only 3,000 lbs. less than the most powerful Pacific type engines on the Pennsylvania Railroad, but weight 70,000 lbs. less. Although they do not have as large a boiler in relation to cylinder requirements as the Pacific type engines, they have ample steaming capacity for the relatively short runs on which they are used. Compared with the maximum cylinder horse-power, the boiler has a rated efficiency of 85 per cent and the grate has a factor of 96 per cent.

On account of their high tractive power, they are able to get away from stations quickly, making them especially advantageous for service requiring frequent stops. Some of these locomotives are hauling heavy trains on steep grades meeting exacting schedules.

50% Cut-Off Locomotives

Locomotives arranged for a maximum cut-off of 50 per cent instead of the usual 90 per cent are not an entirely new development but they deserve special mention at this time because the Pennsylvania R. R. has received from the Baldwin Locomotive Works during the past year over four hundred decapod freight locomotives with this arrangement.

These engines have 30½" x 32" cylinders and a working pressure of 250 pounds.

The total weight in working order is 386,000 pounds

Weight on drivers in working order is 352,500 pounds.

Diameter of drivers, 62 inches.

A paper read before the Canadian Railway Club, Jan. 8, 1924.

The distribution valves of these engines are arranged with an auxiliary port which, for starting a train, permits a cut-off of 80 per cent. This port being restricted in size, its effect begins to diminish immediately after starting and is practically eliminated when the speed reaches 2½ miles per hour.

Compared with a locomotive of the same weight the piston thrust is greater by probably 25 per cent. This makes necessary larger rods, crank pins, crossheads, etc., involving an increase in the revolving and reciprocating weight and more counter-balance in the driving wheels. The effect of this increase in reciprocating weights is of little importance at slow speed, while the greater steam expansion obtained effects an important saving in the operation of the engines.

Observations indicate a coal saving of 20 per cent in slow freight service. They consider that for high speed passenger service, a possible saving of 10 per cent would be neutralized by the negative effect of the 25 per cent increase in reciprocating weights. The most promising field therefore for this type of locomotive is in heavy slow freight service.

Three Cylinder Locomotive on the New York Central

Owing largely to the success of the New York Central's Class K-11 462 type engines in fast freight service (these engines being 26" x 26" with 69" wheel) it was decided, for increased capacity, to try out a 482 type engine on the Mohawk Division between Albany and Syracuse, a distance of approximately 140 miles. It was desired to make this distance with heavy trains in eight hours running time. As the 482 type engine was at that time a new type on most roads and entirely so on the New York Central, it was decided to build a single engine and accordingly the first of the Class L-1 engines on this road, No. 2500, was designed and built by the American Locomotive Company in 1916. The engine was designed for this particular service and its success was so marked that during the years of 1916 and 1917, 139 additional engines with only very minor modifications were built. These engines have been in constant service since that time and owing to the geographical conditions of the Division, are probably the hardest worked engines of this type in the United States. This, of course, is due to the fact that the Division is practically level and the engines are worked with heavy trains and fairly high speeds over the entire 140 miles at their maximum capacity.

Since the receipt of these engines on the New York Central, service demands have, of course, been constantly increasing, finally reaching such a point in 1922 that it was decided to see what could be done toward increasing the capacity of this type of engine for this particular service.

The railway company then asked the American Locomotive Company for its recommendations with the understanding that one of these engines was to be returned to the American Locomotive Company and rebuilt incorporating the recommendations decided upon. This was accordingly done and the engine, road No. 2568, was rebuilt and shipped to the Railway Company September 13, 1922, since which time most remarkable results have been obtained both in service as regards hauling capacity and also fuel and water consumption.

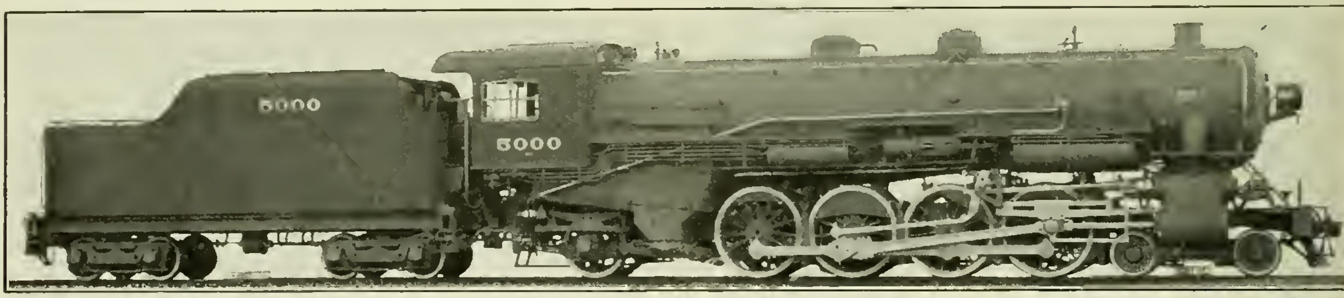
The work done by this locomotive will compare most favorably with the best obtained from any other engine having the same weight on drivers. I might cite as typical performances that this locomotive has hauled trains of 8,000 to 8,500 tons over the division in less than eight hours.

The major changes which were made in the design were as follows: Substitution of three cylinders instead of two; addition of trailer truck booster; addition of Elvin stoker; addition of feed water heater; substitution of type E superheater instead of type A; increase of tender capacity from 8,000 to 15,000 gallons.

The original engines were greatly handicapped by the small tank capacity furnished and too frequent stops were required to take water, accordingly the tender capacity on this engine was nearly doubled thereby obtaining much better service in this respect.

The change in the superheater and the addition of stoker and feed water heater greatly increased the maximum steaming capacity of the engine so that no difficulty has been experienced in this respect in service. In fact the harder the engine is worked, the better she seems to steam.

The results in service have been so marked that it seems reasonable to make the assertion that a three-cylinder engine having the same weight on drivers can be made to deliver at least 12 to 15 per cent more power that the corresponding two cylinder engine. This increase is, of course, mostly due to the more even turning moment of the three cylinders as against two, and the better effect of the exhaust in the stack.



Three Cylinder Mountain Type Locomotive in Service on the Lehigh Valley Railroad—Built by the American Locomotive Company

Three Cylinder Locomotive on the Lehigh Valley

Another three cylinder locomotive has recently been built by the American Locomotive Company and has been placed in service by the Lehigh Valley.

It has the same size cylinders and same boiler pressure as the New York Central engine, described in the December, 1923, issue of Railway and Locomotive Engineering.

The design of the boiler differs considerably, a type A superheater is used, the size of the firebox increased and a combustion chamber applied. The grate area is 25 per cent greater. No booster has been used on this engine. A study of the performance of this locomotive should indicate just how much the use of three cylinders will add to the efficiency of a locomotive without the use of type "E" superheater or the assistance of a booster. The preliminary trial runs of this engine have shown that it will haul a greater tonnage than two cylinder locomotives of considerably higher tractive power. It is a very free steaming locomotive and gets its trains over the division in fast time. These runs were made on the Buffalo division.

The locomotive has hauled a train of 4,500 tons on a long grade of 21 feet per mile and indications are that it may be able to take a train of 5,000 tons over this section.

The following table gives the general characteristics and dimensions of the three-cylinder locomotive No. 5000 on the Lehigh Valley Railroad:

TABLE OF DIMENSIONS, WEIGHTS AND PROPORTIONS

Type of locomotive	4-8-2
Service	Freight
Track gage	4 ft. 8½ in.
Cylinder, diameter and stroke	3—25 in. by 28 in.
Weights in working order:	
On drivers	246,500 lb.
On front truck	66,000 lb.
On trailing truck	56,500 lb.
Total engine	369,000 lb.
Tender	201,000 lb.
Wheel bases:	
Driving	18 ft. 0 in.
Total engine	41 ft. 2 in.
Total engine and tender	77 ft. 8 in.
Wheels, diameter outside tires:	
Driving	69 in.
Boiler:	
Type	Conical
Steam pressure	200 lb.
Diameter, first ring, inside	82½ in.
Firebox, length and width	126⅛ in. by 96¼ in.
Tubes: number and diameter;	230, 2¼ in. and 50, 5½ in.
Length over tube sheets	21 ft.
Grate area	84.3 sq. ft.
Heating surfaces:	
Firebox and arch tubes	392 sq. ft.
Tubes and flues	4,337 sq. ft.
Superheating	1,294 sq. ft.
Tender:	
Style	Rectangular
Water capacity	10,500 gal.
Fuel capacity	15 tons
Trucks	8 wheel
Rated tractive force	64,700 lb.

Feed Water Heaters and Boosters

A very considerable number of the locomotives built last year were equipped with feed water heaters showing that there are many roads ready to install this equipment for the saving that can be obtained. I recall one case where a number of suburban tank locomotives were equipped with feed water heaters because it was undesirable to increase the water capacity of tanks but the service required sufficient tank capacity to make the run without taking water between terminals. The economy in water consumption effected by the feed water heater has given these engines a comfortable margin without increasing the capacity of the tanks.

The application of a booster usually adds from 9,000 lbs. to 11,000 lbs. to the tractive power of a locomotive.

This increased power is available at starting when additional power is most needed. It is also available at slow speeds on grades where the engine may otherwise require a helper. What the booster can do has been shown in actual service many times and its use has been increasing steadily.

The locomotives that I have briefly cited in this paper are ones about which I happen to have some information. They may not be the most notable of the year just past, they are by no means the only notable designs of last year.

Here in Canada on your National Railways a large number of Mikados of a new design with Belpaire fireboxes have been put in service and also a number of Mountain type locomotives of larger size. Reports on the performances of these engines would be of great interest and value. How their fuel rates compare with previous engines, whether they have met the expectations of the officials from an operating standpoint, etc.

If we can take away with us from this meeting a few thoughts that will help us to further improve the engines that will be built this year or next year our evening will have been well spent. We will not find any one design of locomotives, any accessories no matter how important or efficient or any combination of these things that will give us the best locomotive for all roads or all conditions of service. Each railroad, oftentimes each division, has its own particular problems that have to be carefully studied and patiently solved individually. It is a part of successful railroad operation to find the correct solution.

Depreciation of Railway Equipment

By JOHN E. MUHLFELD

The present day application of "Depreciation," for the lessening of price or value, is an indirect method that is frequently used to speculate in the problematical life of property, and which, in that sense, cannot be applied without encountering constitutional obstacles incidental to the confiscation of property.

For railway rate making purposes no account of the depreciated condition of a physical property used for the convenience of the public need be taken or applied to its fair value, as, in order to provide for a proper use of the property, the owners will be obliged and required to properly maintain it out of current earnings, and therefore must of necessity be allowed a sufficient return to insure adequate repairs and renewals, in the form of actually applied material and labor, to make good wasted, worn, fatigued and stressed parts which, if allowed to remain, would cause deterioration.

The Interstate Commerce Commission depreciation accounts have been provided for the purpose of creating reserves to meet or reduce the amounts otherwise chargeable, as may be appropriate, to Operating Expense or to Profit and Loss accounts, to cover property retired. Such depreciation charges shall be based upon the percentage of the original cost (estimated if not known), ledger value or purchase price of equipment, determined to be equitable by the carrier's experience and best sources of information as to the average current loss from depreciation.

The term "Depreciation," in common usage, admits of a variety of definitions, depending upon the purpose of its use and the attitude of mind of the user, and has been associated more particularly with accounting systems until the passage of the Federal Valuation Act. In point of fact it imports a decline in value, that is, a diminution of productive or net earning capacity. For example, the phrase "Accrued Depreciation," as found in the Interstate Commerce Commission Classification of Investment in Road and Equipment, is intended to instruct the Carriers in respect to the setting up of an account for the Replacement of Equipment, and not for the purpose of setting up a fund for its upkeep. Therefore, it would seem that a "Replacement Account" would more clearly and definitely define the intent for the setting up of the fund.

The introductory letter of the Statistician of the Interstate Commerce Commission, speaking of The Classification of Operating Expenses as prescribed by the Interstate Commerce Commission in the Third Revised Issue of 1907, pages 10-11, reads as follows:

> "1—The question of depreciation is fundamentally a *question of values,* and not a question of maintaining the original capacity, or of a standard of operating efficiency, or of keeping full the numbers in equipment series."
>
> "2—The depreciation rules may be worked either on the basis of the value of individual cars and locomotives, or on the basis of the value of series of cars and locomotives. On this point accounting officers are at liberty, until advised to the contrary, to follow whichever method seems to them the more appropriate."
>
> "4—The application of depreciation charges for the current year and subsequent years must not be influenced by the practice of years past. In case property has been appreciated by excessive charges to operating expenses in the years past, the value thus placed in the property must be regarded as a permanent undivided asset to the stockholders. On the other hand, in case property has depreciated on account of insufficient charges to operating expenses in years past, this fact must not be permitted to influence the determination of the depreciated rate for the current year."

It will be observed that this statement by the Statistician suggested that the expenditures for excessive charges to maintenance of equipment account in past years is evidence of *value,* for the apparent reason that when repairs are punctual and adequate, and renewals are in proportion to the average life of materials, operating expenses have fully discharged their obligations to the equipment and there has been no failure on the part of a material agency in the performance of its function for the reason that a condition of undiminished capacity has been maintained, and existing depreciation, if any, has resulted only from causes other than physical exhaustion.

The evolution of equipment in the way of size, capacity, design, material and construction, particularly as the result of new inventions, governs largely as to obsolescence and inadequacy. For example, the basis of comparison of the present day fighting value of warships is that of displacement, and which has a clearly defined value at the date of a ship's completion *only*. The reason for the change in this value is that from the date a warship takes the water there sets in a steady and very rapid depreciation of its military efficiency, due to obsolescence and inadequacy. No piece of equipment embodies such skilled design and such carefully selected materials as a modern warship, and none receives such careful upkeep or involves the expenditure of greater sums for repairs and refitting at regular recurring periods. Therefore the rapid depreciation is not due to material or maintenance, but is due largely to invention. In fact, the more modern a ship the shorter its tenure of useful life—on account of unforeseen inventions for which no provision can be made in design or construction at the time that it is built. We have only to look at our own and at Great Britain's naval budgets, and to the fact that a capital ship is worthless for active service after fifteen years from the date of completion, in order to realize the effect of obsolescence and inadequacy, and not the effect of material and maintenance, in calculating depreciation.

In the Interstate Commerce Commission, Division of Statistics and Accounts, Accounting Series Circular No. 13, issued as of July 20, 1907, Professor Henry C. Adams, in charge of Statistics and Accounts, in explaining and stating the purpose of depreciation accounts, says: "For a carrier that in the past *has maintained its property,* there can be no increase in operating expenses on account of depreciation charges, for the reason that the sum of the charges to the three primary accounts, 'Repairs,' 'Renewals,' and 'Depreciation' under the new classification will equal the amount which under the old classification would have been charged to the primary account—'Repairs and Renewals.' "

While Professor Adams did not so state, he undoubtedly in this statement had in mind the older railroads where the retirement of equipment shall have commenced, and where the annual charge to operating expenses, resulting from retirements, approximate what the depreciation charge might be on such classes of property. Certainly until a railroad has attained, annually, the average of its retirements, any charges to operating expenses for depreciation will inflate the operating expenses if sufficient current expenditures are made for current maintenance.

The Classification of Operating Expenses as prescribed by the Interstate Commerce Commission, in accordance with section 20 of the Act to Regulate Commerce, Third Revised Issue, dated 1907, and Supplement to same effective July 1, 1908, in stating a uniform system of accounts also defines the Depreciation Accounts of Equipment "to include a monthly charge of one-twelfth (1/12) of per cent per annum of the original cost (estimated, if not known), record value, or purchase price of equipment, to provide a fund for replacement when retired" and "that charges should be made to this account during the life of the equipment except in cases of equipment which attains to greater than a normal life; in such a case charges should cease when the difference between the original cost, record value, or purchase price and the estimated scrap value shall have been charged to this account."

The foregoing therefore leads to the proper conclusion that:

(a) Depreciation accounts are for accounting purposes.

(b) Such accounts are to create a fund for renewals at the expiration of useful life and do not contemplate deductions from Capital Accounts.

(c) No charge is to be made on account of Depreciation, provided that repairs and renewals, as theretofore understood, are adequate.

(d) Monies represented by depreciation reserves, which may not have been reinvested in the property, will be included in Capital investment.

According to this theory the effect and presumptive purpose of the Depreciation Accounts are:

First — To distribute the maintenance charge over the traffic accommodated by it, and

Second—To prevent an overstatement of income which would enable the declaration of a dividend from Capital.

Therefore, so far as I know, depreciation has been required by the Interstate Commerce Commission not for the purpose of determining value but as *anticipated maintenance,* for the purpose of covering an intangible quantity which cannot be determined or measured because of its deferred maintenance condition, or obsolescence, or inadequacy, and to provide a fund into which maintenance can be charged and accrue, the sole effect being to apportion the maintenance cost to the entire service performed. Furthermore, as obsolescence or inadequacy are not functions of age or upkeep, for the reason that a locomotive or car, regardless of its age or maintenance condition, may become obsolete or inadequate, or both, at any time when in the best judgment of the owners it is unsuitable for the service required, any measure of depreciation must therefore be on the basis of whether or not the equipment has been maintained to an appropriate standard of operating condition, and with respect to its suitability and adequacy to meet the performance requirements. These factors must be determined first through the physical condition of the simple as well as of the composite or assembled parts making up each piece of equipment as a whole, which condition must then be converted into *value* in terms of dollars and again properly equated for the purpose of correcting any differences in the *value* of a *dollar*, thus insuring a proper final figure.

During a general conference—at which various steam road mechanical department heads, including myself, were present—with Professor Henry C. Adams, in charge of statistics and accounts of the Interstate Commerce Commission, at Washington, D. C., prior to the revision of the classification of steam road disbursement accounts, as presented by the I. C. C. (subject to the provision of the Act to Regulate Commerce as amended June 29, 1906) and the establishment of the existing I. C. C. accounting system, effective as of July 1, 1907, Professor Adams inquired as to our views on the setting up of a depreciation account for locomotives and cars. The information given him was to the effect that so long as the necessary general and running repairs and renewals were made, no depreciation accounts, except to cover obsolescence or inadequacy of equipment, should be set up, inasmuch as any depreciation which obtained, due to other than obsolescence or inadequacy, would be made good from time to time by repairs and renewals on operating account, and which would be charged to the Maintenance of Equipment expenses. We furthermore contended that if depreciation accounts were set up and included in the Maintenance of Equipment expenses, same would tend to cause deterioration and deferred maintenance of equipment for the reason that we would not have the amount of money covered by such charge to utilize in *actual applied labor and material for upkeep,* and that therefore more damage would be done in the way of resulting deferred maintenance of existing live equipment than could be gained from the creation of an Accrued Depreciation-Equipment reserve.

Our ideas and comments, however, apparently did not impress Professor Adams, for the reason that the depreciation accounts in Maintenance of Equipment Expenses and the Accrued Depreciation-Equipment reserve were established and since which time existing locomotives and cars have not benefited from the application of the amounts represented thereby for actual upkeep in the form of *applied labor and material.*

At the present time, under the I. C. C. Rules, when a so-called book charge is made to Operating Expenses for depreciation of equipment, this same amount is credited to Accrued Depreciation-Equipment and the amount credited to this reserve, on account of each particular item of equipment, stands in the reserve until each such particular item of equipment is destroyed or is otherwise retired from service; after which the ledger value is credited to Property Account and the amount of depreciation which has been charged to Operating Expenses and credited to the reserve is charged to the reserve and the balance of the ledger value, less salvage, is charged to Operating Expenses, Equipment-Retirements. Therefore, the balance remaining in the account of Accrued Depreciation-Equipment at all times represents the depreciation on existing or live equipment which has been charged to operating expenses, and may be drawn upon for additions and betterments to existing equipment, for the purchase of new equipment, and probably for improvements to fixed property, if so desired. It cannot, however, be drawn upon for any purpose other than for the creation of, or for the acquisition of, assets, and when expended for such purposes the cost of such assets must be charged to the Capital Asset account and not to any other account. For example, in the case of a typical steam railway, 2 per cent per annum is the rate of depreciation established to provide for obsolescence, inadequacy and contingencies on all equipment acquired prior to Federal Control; and the rate of 4½ per cent per annum is the rate charged for all equipment acquired during Federal Control, this rate having been established during Federal Control by the Division of Accounts, U. S. R. A. When any piece of equipment is retired the ledger value is credited to Property Account and the amount of depreciation which has been charged to Operating Expenses and credited to the Accrued Depreciation-Equipment reserve is charged to this reserve. The balance or the ledger value, less salvage, is charged to Operating Expenses, Equipment-Retirements.

Prior to the I. C. C. instructions effective July 1, 1907, Major H. D. Bulkley, Comptroller of the Baltimore and Ohio Railroad Company, had inaugurated on January 1, 1904, on that system, the best and most sound system of capital and operating account equipment charges and credits that has yet been devised. Under Major Bulkley's system of accounting, nominal Equipment Reserve funds were set up to provide only for emergencies. There was no "estimating" of the service life or "speculation" as to the future usefulness, value of physical condition of live equipment, thus depriving it of labor and material needed for current repairs and renewals, for the purpose of setting up reserve funds, and which latter are the cause of otherwise avoidable physical deteriorations and damage, and result in premature retirement or increased cost for upkeep and loss of potential usefulness. In general, under Major Bulkley's plan, when additional equipment was acquired the record and cost of each piece was entered in the Equipment Ledger and charged to Equipment Account. Any additions, betterments or deletions made from time to time were properly recorded and charges or credits made accordingly. The cost for all equipment and appurtenance repairs was charged to Maintenance of Equipment Expenses, and when any piece of ownership equipment was retired for any cause, Equipment Account was credited with the cost as shown in the Equipment Ledger and a corresponding charge, less salvage credits, made to Expenses. Also when equipment belonging to a "Trust" was retired for any cause its value was replaced and similarly charged to Expenses. When a piece of equipment unfit for service, was rebuilt its Equipment Ledger cost was credited to Equipment Account and charged to Expenses and its rebuilt cost was charged to Equipment Account and entered in the Equipment Ledger as a new addition. Likewise when a piece of equipment, unfit for service in the class to which it belonged, was changed to another class, the accounting and recording were similarly handled.

The fact that Major Bulkley's system was sound is evidenced by the general condition, performance and economy of equipment upkeep on the Baltimore and Ohio during the five year period following its inauguration.

As is evident from the natural distinction between capital and operating expense accounts accrued wear and tear that is made good from time to time by current repairs and charged to maintenance, cannot be considered as depreciation. For example, locomotives with a cost of reproduction new of from $12,000 to $37,000 each, as of June 30, 1916, are, on June 1, 1916, in need of general repairs and renewals which will cost from $2,300 to $5,900 each at prices representive of that period. The deduction of the cost to make good the accrued wear and tear, from the Cost of Reproduction New, would leave the so-called "Depreciative Value" of the locomotives only from $9,100 to $31,500 each. This would be entirely wrong, for the reason that when the locomotives are turned out of the shop with the necessary repairs, during the period immediately following June 30, 1916, and *which repairs will have been charged to Maintenance*, they will again have a Cost of Reproduction New value of from $12,000 to $37,000 each, as of June 30, 1916, and without any credit whatsoever to capital account. In the case of accrued wear such as, for example, takes place on driving wheel axles and tires, and which is not made good at each shopping, but at certain intervals, by renewals or otherwise, the same reasoning must apply, from the fact that such renewals when made are properly chargeable, and are charged, to Maintenance.

Furthermore, any attempt to credit Depreciation and charge Maintenance Accounts with the cost for accrued repairs and renewals, such as take place on driving wheel axles and tires and which cannot be made economically as of each date of shopping, is erroneous, as until such accrued repairs and renewals reduce the Appropriate Standard of Operating Condition or the Net Earning Capacity, or both, of the property, it is not a proper credit to Capital Account.

Therefore, from an accounting standpoint, when depreciation charges are set up against monthly or annual operating expenses to cover accrued wear, tear and the like, then, as such physical conditions are made good through maintenance, the asset value of the equipment affected should be properly *appreciated*. Otherwise a double or improper charge will obtain against operation.

The Romans discovered cement and concrete mixing, which is today largely used in railroad building and roadway structures, before the time of Christ, and used it in the construction of the Pantheon in Rome which, with its concrete dome of equal height and diameter, i.e., 142 feet, resting on circular walls of brick and cement mortar, still stands; also in many other great structures that they built about that time. Likewise their masonry construction, which is also largely used by railroads, is represented by the Roman Aqueducts, some of which are 60 miles long, over 200 feet in height, and have stood 20 centuries of time. They still bring water into Rome, and are evidence of the service life that can be obtained from this class of work.

Automobiles are also passing across the masonry bridge built over the River Jordan by the Jews over 3,000 years ago. Adjacent thereto a hydro-electric power plant has recently been contsructed about eight miles below the Sea of Galilee.

It would have been quite impossible at the time of the building of these masonry and concrete structures, from 30 to 20 centuries ago, to have determined upon any rate of depreciation to be applied to their life. Who, today, can determine what rate of depreciation, either "straight line," or otherwise, should be applied to any one of these structures? Likewise when a locomotive or car can be, and is, maintained to perform the necessary service for which it was originally designed and intended, or otherwise has been adapted to (as has been actually accomplished by various existing motive power and rolling stock during the past fifty years), only such obsolescence or inadequacy as will destroy its fundamental usefulness justifies depreciation or retirement charges to expenses.

Wooden railroad structures also have a problematical life. For example, the Wabash Railroad Shops at Fort Wayne, Ind., where about 35 years ago I served my time as machinist apprentice, are of brick and wooden construction and the original wooden buildings are still in existence and being utilized for the same purpose for which they were designed and constructed.

The theory that the oldest structure is the worst and the newest the best is a fallacy. For example, age, in combination with upkeep charged to expenses brings appreciation, not depreciation, in a railway or highway subgrade. Amortization charges are proper where a property is permitted to run down and eventually become worthless, but maintenance charges paid from current earnings are in themselves amortization. Likewise when an accounting charge is made against expenses for "depreciation," when such "depreciation," in whole or in part, is made good by maintenance, the "appreciation" should be credited to expenses.

The misapplication of the theory of "straight line" depreciation to a railroad represents permanent impairment of capital which can never be restored and is a confiscation of composite property having a problematical length of life. Otherwise when are such railroads as those that go to make up the New York Central and Pennsylvania Systems to be scrapped and new transportation machines substituted.

A composite mobile structure, such as a locomotive or car, when properly maintained, is kept in existence by the continued renewal and repair of its simple parts which wear, waste away, or are destroyed piece-meal from time to time, and the cost is charged to expenses. Furthermore, during the past ten (10) years, the hauling capacity and efficiency of the steam road motive power in the United States has been increased by the majority of the railroads by conversions and improvements of thousands of existing steam locomotives in order to bring this older power up to the standard of the more modern equipment. For example, in the case of a certain lot of Consolidation freight locomotives, which eighteen (18) years ago cost new about $18,400.00, their recent modernization through the application of increased boiler pressure, piston valve cylinders, superheaters, brick arches, Walschaerts valve gear and various minor improvements enables them now to haul 3,000 as compared with 2,300 equated tons per train; and also to operate about 30 per cent more economically with respect to fuel, repair, and other working and maintenance costs per gross ton mile, with the result that the net earning capacity of each locomotive in that regard has been increased, on an average, about $57,000.00 per annum as compared with its previous performance as originally constructed.

PHYSICAL CONDITION of COMPOSITE PROPERTIES SUCH AS LOCOMOTIVES AND CARS

In the designing and building of the different types and capacities of locomotives and cars, fundamental factors are—

1—Proper factors of safety,
2—Effective distribution and disposition of material,
3—Chemical and physical specifications and tests of detail material,
4—Inspection and testing of the final assembly of parts.

The *factors of safety* to be used in the designing, distribution and disposition of the material in the detail parts are most important elements, for the reason that these factors must not only provide adequate safety and maintenance in operation, but *must further provide* an adequate margin of strength to take care of the atomic or molecular differences and changes in the material used. For example:

A—Original inherent defects such as pipes, blow-holes or physical or chemical segregation are covered by this factor of safety.

B—The fatigue in parts subject to repeated dynamic strains is covered by this factor of safety, in combination with periodical heat treatment when required.

C—The fatigue in parts, due to heat, is covered by this factor of safety, in combination with repairs and renewals as required.

D—Corrosion, due to oxidation or other chemical action, is covered by this factor of safety, in combination with repairs and renewals as required.

In general, in the designing of steam locomotives, the factors of safety used range from 4 to 8 for various principal parts such as:

Boiler shell	—Factor of Safety of	4½
Boiler staybolts	— " " " "	6 to 8
Boiler tubes and flues	— " " " "	6
Cylinder bodies	— " " " "	5
Engine frames	— " " " "	6 to 8
Axles (with ⅜" wear on original diameter)	— " " " "	5
Crank pins	— " " " "	5
Main and side rols	— " " " "	5
Valve gear	— " " " "	5
Tires	— " " " "	Beyond requirements of good practice
Other parts subject to original inherent defects, fatigue, erosion and corrosion	— " " " "	4 to 8

Various factors which affect the wear and tear and the upkeep cost for steam locomotives may be stated as:

1—The human element factor in operation and inspection—which may increase or decrease the normal wear, tear, loss and damage on boiler and machinery parts such as firebox sheets, flues and tubes, grates, ash-pans, tires, journals, shoes and wedges, guides and crossheads, piston and valve rod packing, piston valve and cylinder packing, main and side rod bearings, motion gear, and the like. For example, the human element factor in the regulation of the water level in the boiler determines as to the wear and tear on the superheater, piston valves and cylinders. The same factor in the use of lubricants determines the wear and tear on cylinder and valve parts, journals and bearings.

2—The kind of gradient and curvature over which the locomotive must operate affects the flange, as well as the tread, wear on tires and wheels.

3—The surface, alignment, guage and condition of track rails affects the wear on tires and wheels.

4—The kind of fuel determines the extent of erosion and corrosion of firebox sheets and boiler tubes and flues.

5—The quality of boiler water determines the time between the renewal of boiler and firebox plates and stays and the re-setting of boiler tubes—which, in many cases, vary from one to ten or more years.

A steam locomotive is composite property made up of an assembly of simple properties or parts of different design, material, strength and value, and these detail parts may or may not be subject to deterioration on account of use or non-use. For example, certain non-wearing parts, such as various iron and steel castings, undergo no replacement except on account of original indifferent design, material or manufacture, or as the result of casualty, whereas other wearing parts, such as valve and cylinder packing rings and brake shoes, require frequent replacement and have relatively small new or salvage value, while other wearing parts, such as driving box crown, and main and side rod brasses, require frequent replacement and have a relatively large new and salvage value.

So long as equipment performs its function it has not lost any of its value to the carrier. Therefore, much depends upon the standard of excellence of repair in which a railroad maintains its equipment and the extent to which constant repairing and renewing of worn, fatigued, stressed and wasted parts make good deterioration.

From calculations made at different times, on the basis of weight and cost, locomotive parts which must, from time to time, be removed and renewed in whole or in part, represent from 30 to 40 per cent of the total value of the locomotive, and Exhibit "A" has been prepared to show how these parts may be listed, as regards physical treatment, for the purpose of continuing the complete locomotive in unimpaired condition indefinitely, so far as its original design, material and construction, and its productive earning capacity are concerned, without other than a normal cost for maintenance and operation, subject, of course, to its renewal from service on account of obsolescence, inadequacy, casualty, or for some other reason discretionary with the owners.

In addition to the listing given in Exhibit "A" we must also differentiate between steam locomotive wear, tear and wastage which is regularly made good at each classified repair shopping, such as resetting boiler tubes, renewing boiler stays, turning driving and truck wheel tires, refitting driving box crown and end play bearings, renewing piston valve and cylinder packing, re-fitting crosshead shoes and guides, re-fitting and renewing main and side rod brasses, and the like, and that wear, tear and wastage which accrues but need not, and also cannot economically, be made good at each classified repair shopping, such as the re-setting of boiler flues and the renewal of boiler flues, tubes, superheater elements, driving box crown brasses, driving box shoes and wedges, tires, wheels valve chest and cylinder bushings, crosshead shoes, fireboxes, front flue sheets, smokebox liners, and the like. The potential life, use and treatment of certain steam locomotive simple properties such as a boiler tube or flue, tire and axle, and of certain composite properties, such as a firebox, must also be given full consideration. In addition to wear, tear and wastage, the factor of established rules and regulations will affect the life of parts, as for example, boiler tubes and flues, which, according to the Interstate Commerce Commission instructions, must all be removed from each boiler at established times, unless otherwise authorized, regardless of their physical condition, in order to make periodical interior examination of the boiler in addition to the annual hydrostatic test.

In the typical case of a Consolidation type of freight locomotive, representative of about fifty (50) locomotives of the same class, the cost for classified repairs during a ten (10) year period was distributed as follows:

Cost of new material applied in place of parts removed	$16,610.23
Cost of labor to remove old and apply new material	11,663.00
Cost of labor to repair and refit parts that were not renewed	2,969.16
Value of salvage and scrap removed	1,685.78
TOTAL net cost of material	14,924.45
" " " " labor	14,632.16
" " " " material & labor	29,556.61
" " " " new material and labor to remove old and apply new material, exclusive of salvage and scrap credit	28,273.23

As this locomotive cost the railroad, when new built, approximately $18,400.00, of which figure the cost of the unassembled material at that time represented about $9,-400.00 or 51 per cent, it will be realized to what extent, during the life of a locomotive, the renewal of material subject to deterioration takes place in the process of repeated classified repairs and that practically no opportunity exists for any depreciated simple parts to be continued in use when a composite piece of machinery, such as a locomotive, is maintained in serviceable condition.

Chart "A" has been prepared to show the effect of the difference in the average wear, tear and life of the various simple and composite parts and appliances of one class of locomotives, on the years of service and the assumed average value of the particular lot of locomotives involved. This exhibit differentiates particularly between the accrued wear and tear on those parts which cannot, economically, and need not all, be restored at each shopping, in order to maintain an appropriate standard of operating condition or of earning capacity, and the accrued wear and tear on those parts which must be more frequently refitted or renewed.

Chart "B" shows the effect of age, conditions and betterments and classified repairs on the maximum starting power of a steam locomotive, which gives the hauling capacity and thermal efficiency as shown on Charts "C" and "D."

Chart "C" shows the effect of age, additions and betterments and classified repairs, in the same locomotive, on the maximum hauling capacity at a speed of fifteen (15) miles per hour.

Chart "D" shows the effect of age, additions and betterments and classified repairs, in the same locomotive, on the percentage of power delivered at the rail to 100 per cent of the heat value of the coal as fired. The decrease in the thermal efficiency, between shoppings, illustrates the effect from the gradual fouling of the boiler and the accumulation of lost motion, due to wear and tear on the valve gear, that cannot economically be made good from month to month by enginehouse repairs, and which affects the adjustment of the valves and the distribution of the steam in the cylinders. Leakage of steam through piston valve and cylinder packing, and through valve and piston rod packing, has not been considered, as these parts should be constantly maintained in good condition.

Chart "E" compositely illustrates the typical periodical accrual and restoration of locomotive wear, tear and wastage, starting and hauling capacity, and thermal efficiency, as set out on Charts "A," "B," "C," and "D." In addition, the diagonally disposed broken line shows the I. C. C. rate of "straight line" depreciation on the basis of the life of the locomotive being determined at twenty-eight (28) years and the salvage or scrap allowance value being placed at ¾ cents per pound of light weight of engine and tender.

Charts "B," "C," "D," and "E" are merely diagrammatic and are conditioned on a single class of Consolidation type of locomotive operating under like climatic, service, gradient, curvature, mileage, tonnage rating, water, fuel and other operating and maintenance conditions. However, they bring out the fact that a locomotive, properly maintained, will have the same starting and hauling capacity and thermal efficiency, regardless of age, and therefore is not subject to depreciation, except on account of obsolescence or inadequacy.

Exhibit "A"

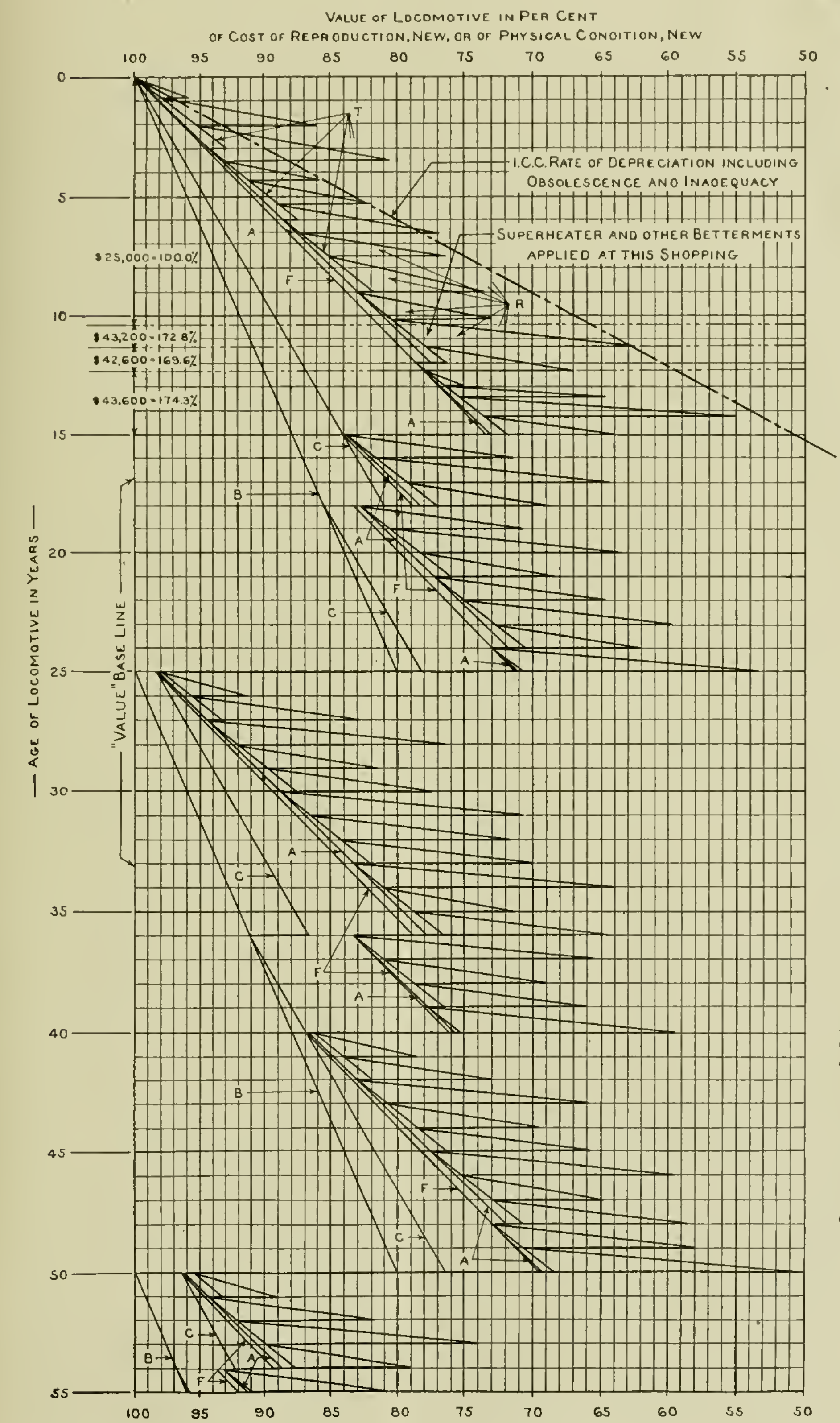
Potential Life and Treatment or Certain Simple Properties Which Collectively Enter into the Construction of a Steam Locomotive, or Composite Property

LIST OF STEAM LOCOMOTIVE PRINCIPAL PARTS

Group	Which Have the Maximum Life and Require Relatively Few Repairs or Renewals	Which Have an Indefinite Life and Require Re-fitting from Time to Time	Which Have a Definite Life and are Frequently Re-fitted, or Otherwise Scrapped and Renewed
Boiler	Boiler shell sheets, stays and braces Smokestack castings Smokestack extension castings Dome cap Dome casing Smokebox castings Smokebox door ring Mud-ring Dry and throttle pipes Steam and exhaust pipes Waist sheets	Smokebox fronts and doors Grate bearing bars and supports Grate rigging Ash-pan rigging	Smokebox liners Smokebox draft appliances Boiler lagging Boiler jacket Firebrick baffle walls Ash-pans Rocking and drop grates Flues Tubes Firebox sheets Front tube sheets Firebox staybolts
Machinery	Engine frames Cylinder bodies Engine frame bumpers Engine frame cross-ties and fillers Engine frame deck castings Guide yokes Guides Cylinder and valve chest heads Cylinder and valve chest head castings Piston valve bodies and heads	Main and side rod bodies Main and side rod straps Crossheads Motion gear parts Frame pedestal caps Rocker arms Tumbling shafts Certain bolts, nuts and other fastenings	Piston and valve rods Crank and wrist pins Certain bolts, nuts and other fastenings Piston heads and packing rings Piston valve bull and packing rings Cylinder bushings Valve chest bushings Main and side rod brasses, pins, bushings and bolts Crosshead shoes Motion gear bearings, bushings and pins
Running Gear	Wheel centers Wheel center counterweights Truck frames and bolsters Truck radius bars Equalizers	Center plates and side bearings Brake rigging Brake beams and heads Equalizer hangers	Springs Driving boxes, shoes and wedges Driving boxes, crown brasses and end play liners Axles Tires Truck journal boxes Truck journal bearings
Tender	Tender tank shell Tender frame castings Truck frames and bolsters Tender tank swash plates Tender tank braces	Tender frame sections Center plates and side bearings Brake rigging Brake beams and heads Certain bolts, nuts and other fastenings Coal gates Coal guards	Tank valves Tender tank coal space Truck cast wheels Certain bolts, nuts and other fastenings Truck journal boxes Truck journal bearings Shovel plate Truck springs
Special Equipment	Superheater header Firedoors and frames Air reservoirs	Air pumps Fire door rigging Power grate shakers Injectors Safety valves Lubricators Boiler checks Throttle valves Throttle valve rigging Boiler mountings Whistle rigging Certain air brake parts Certain special appliances	Power reverse gear Mechanical stoker Couplers Draft gears Brake shoes Piston and valve rod packing Certain air brake parts Certain special appliances Superheater elements Superheater unit bolts [illegible]eater damper gear
Miscellaneous	Whistle Sand boxes Bell yokes Pilot brackets and braces Hand rails Ladders	Steam pipe castings Exhaust pipe castings Cabs Running boards Engine and tender drawbars	[illegible]er cocks [illegible]d grease cups [illegible] [illegible]g and varnishing

Chart "A"
STEAM LOCOMOTIVES

TYPICAL ACCRUAL AND RESTORATION WEAR AND TEAR CHART
BASED ON AGE OF LOCOMOTIVE SHOWING CYCLE CHANGES IN PHYSICAL CONDITION
IN PER CENT OF NEW CONDITION AND IN PER CENT OF COST OF REPRODUCTION, NEW



Age of Locomotive in Years	Physical Condition Per Cent	Condition in Terms of Reproduction Cost less Accrued Wear and Tear	Condition Per Cent in Terms of Original Cost less Accrued Wear and Tear
0	100.0	$25,000	100.0
5	84.5	21,100	84.5
10	74.0	18,500	74.0
15	84.0	36,600	146.5
20	78.5	—	—
25	97.5	—	—
30	88.5	—	—
35	78.5	—	—
40	87.0	—	—
45	77.3	—	—
50	95.2	—	—

The Reduction in Physical Condition and Value for each the Boiler, Firebox, Cylinders, Axles and Tires is shown separately, as indicated.

Renewals of all other Parts and Classified Repairs are separately represented and marked as "Classified Repairs" (R)

The "Value" Base of the entire Locomotive is, at all times, the Cost of Reproduction, New, or the Physical Condition, New.

Factors of Obsolescence and Inadequacy have not been considered in preparation of this Chart.

Values and Physical Condition Per Cent are indicated by the Horizontal Lines.

I.C.C. Depreciation Line is based on 28 Years Total Life and on Salvage Cost and Physical Values being 9.65 Per Cent of Original Cost and Condition.

Service Life of
B - Boiler —— 25 Years (Est)
F - Firebox —— 15 "
C - Cylinders — 18 "
A - Axles —— 12 "
T - Tires —— 3 "

Estimated Average Period between Classified Repairs (R) 1 Year.

4—March—1921

Charts "B," "C" and "D"

STEAM LOCOMOTIVES

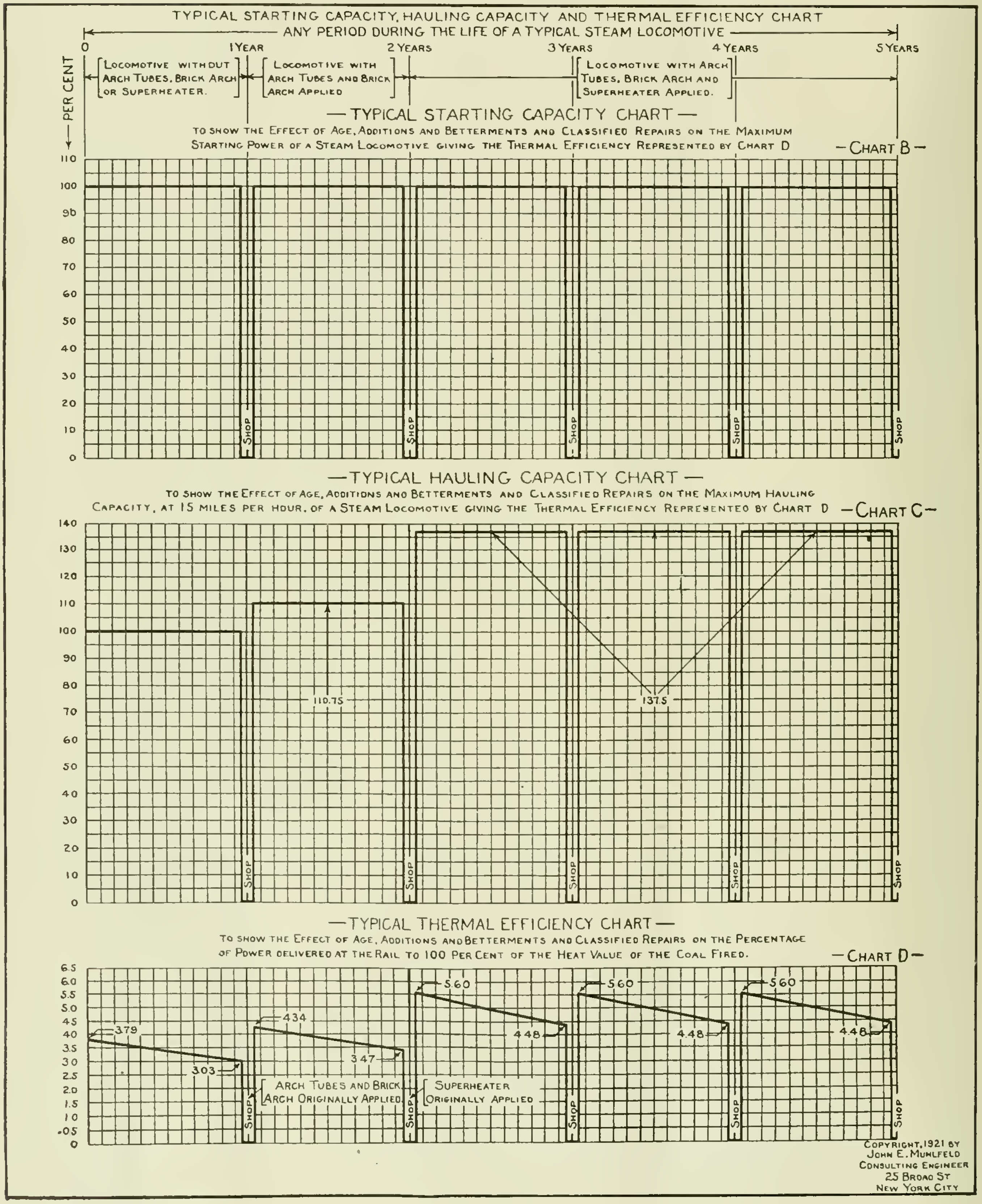
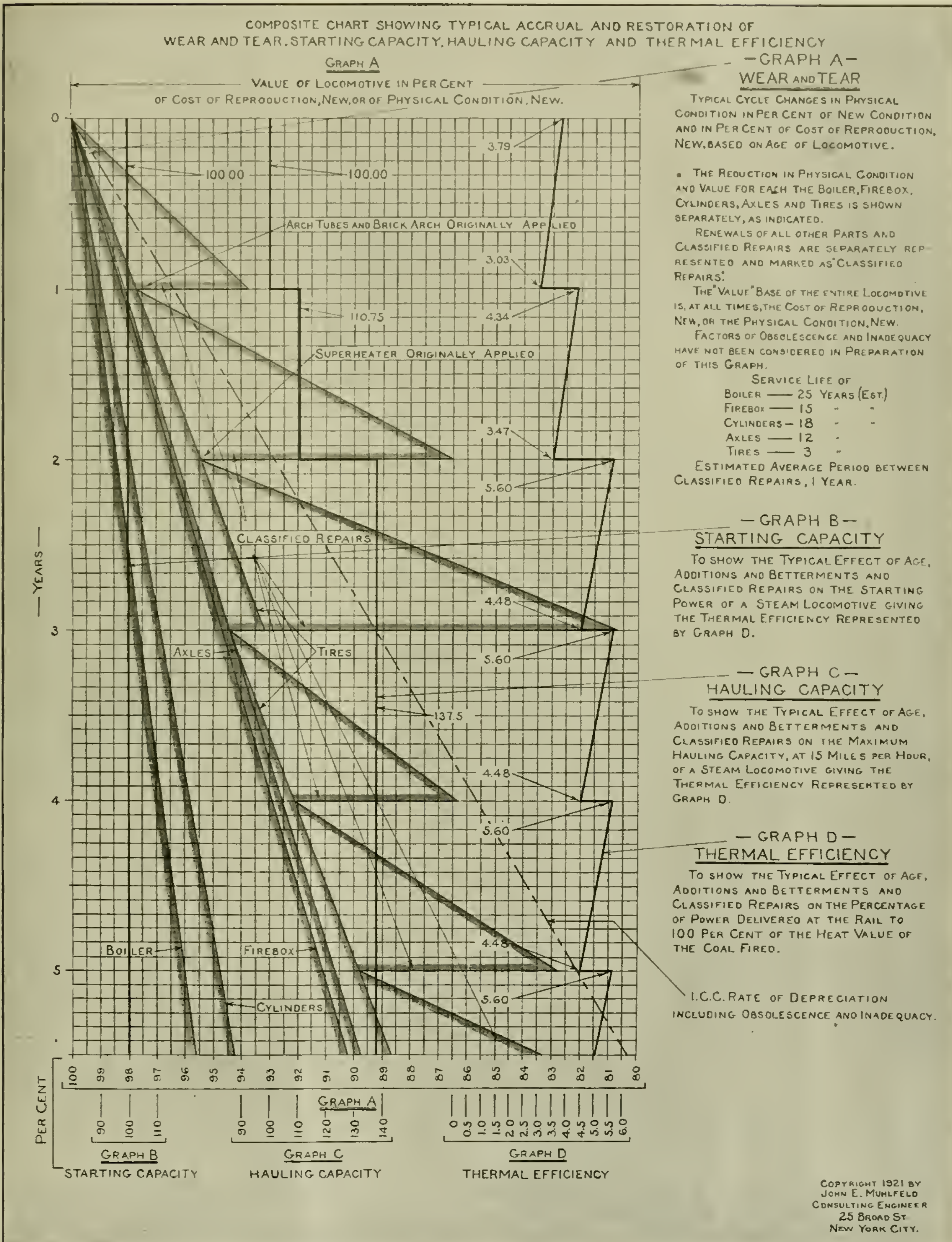


Chart "E"
STEAM LOCOMOTIVES



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Railroad Efficiency

The report of the National Transportation Institute, an abstract of which is published on another page, should prove interesting reading to all who are, in any way affiliated with railway work. To those we believe that the railroads are doing fairly well, that the officials are honest, sincere and earnest men, doing their best, and that, given a chance, they will do even better in the future than they have in the past; the report will come as a corroboration of their beliefs and a story for their faith in future accomplishments. But those, whose creed is one of damnation; for whom the railroad is merely a subject for flamboyant vituperation, and a means of creating dissatisfaction among the unthinking mass, must read such a report as this with a feeling closely akin to chagrin.

To be shown in cold-blooded figures that with a lower capital ratio to output, and with the greatly increased personnel the railroads are doing more work per man and per dollar invested than they did twenty years ago, must be a cause of jubilation or humiliation according to the point of view.

The fact will probably come as a surprise to most people.

There is one point in the report that offers some food for thought.

Ever since the memory of man runneth not to the contrary, there has been a group of conservatives who have thought that the weight of the locomotive had reached its ultimate limit. They were badly disconcerted for a time, however, starting a little more than thirty years ago, while the weight and tractive effort of locomotives were advancing by leaps and bounds. So rapid was this increase that our ideas had to change over night and our figures needed a revision almost every morning.

But we see in this report that while the total tractive effort of all of the locomotives had increased from 100 to 297 per cent in eighteen years the revenue tons moved one mile per unit of tractive power in 1920 was only 90 per cent of what they were eighteen years before.

There are so many elements entering into this matter that it is very unsafe to jump at conclusions. To argue from it that the locomotive had exceeded its weight of maximum efficiency would be absurd, because the report itself shows that the economic efficiency has been increased.

But if a further investigation shows that the locomotives have been working up to their virtual capacity, and that they cannot haul as much per unit of weight as they did, then there must be a point where the economic lines of falling tractive efficiency and rising efficiency of the personnel cross, and it is there that the maximum economic value of the locomotive will probably be found. But it would, indeed, be a bold man who would maintain that it has been reached.

There are interesting statistical matters, but overshadowing them is the fact that, in spite of the close personal supervision exercised, and personal interest usually involved in industrial work, the efficiency per person has increased more on the railroads than elsewhere. Certainly that speaks well for the men in charge. It will be interesting to see what, if any, comments those who make a business of belittling railroad management, will have to say about it.

The Mercury Steam Engine

It has been a favorite occupation of inventors, for more years than a few, to attempt to find a substitute for water, whose vapor should be used as a means of engine propulsion. The general idea underlying most of these schemes was to use a liquid having a low boiling point and latent heat, thereby avoiding the losses incident to the use of water. It must have been fully fifty years ago that ether was suggested and tried for the purpose. Its boiling point was only 95 degrees Fahr. and its latent heat of evaporation was but 163 thermal units. Alcohol and bisulphide of carbon have both been used though both boiling point and latent heat of evaporation were higher than ether, but even in the case of alcohol the latent heat was only a little more than a third of that of water.

None of these schemes were successful either mechanically or commercially although they could be made to work after a fashion, and all were proclaimed as fully developed and ready for practical operation to say nothing of the sale of stock in their respective companies.

It is about twenty-five years since we have heard much, if anything, about these schemes. But now a new claimant for attention has arisen under the aegis of the General Electric Co. It differs from all of its predecessors in two important particulars: First, it is declaredly in an experimental stage, and even the engineer who is at work on its development writes that "it is hoped that successful continued operation of this plant (Hartford Electric Light Co.) may be accomplished and such accomplishment would constitute an important demonstration since the great economies of such a process, if practicable, are obvious."

The second point of difference lies in the use of mercury as the primary liquid. Mercury boils at 675 degrees Fahr. and has a latent heat of evaporation of 117 British thermal units, as compared with 966 heat units for water.

The general scheme is to use a mercury boiler in which the mercury is evaporated and at a pressure of 35 lbs. per square inch, at which it is used to drive a mercury turbine. The mercury leaves its boiler with a temperature of about 812 degrees and after having done its work in the turbine it, at a temperature of 414 degrees and under a vacuum of 29 inches, is made to pass through a steam boiler in which it generates steam at a pressure of 200 lbs. per sq. in. which by passing through a superheater reaches the steam turbine at boiler pressure and 100 degrees of superheat.

The mercury boiler is fired by oil and has a furnace temperature of about 2,700 degrees. After leaving the boiler the flue gases pass to a mercury heater, thence over the steam superheater to a feedwater heater and thence to the stack.

It is a complicated arrangement but the promises of final economy are so great that there seems to be every warrant for prosecuting the experiments.

To give an idea of the possibilities it may be said that, if we make a comparison with a steam turbine generating plant, using 200 lb. steam pressure, with the highest standards of efficiency in turbines and auxiliaries, the mercury steam combination with 35 lb. gauge pressure in mercury vapor should give about 52 per cent more output in electricity per pound of fuel. And, if in such a plant the boiler room is reequipped with furnaces and mercury apparatus arranged to burn 18 per cent more fuel, the station capacity with the same steam turbines, condensers, auxiliaries, water circulation, etc., would be increased about 80 per cent. As compared with higher steam pressures, such as are now being developed, the percentage of gain would naturally be less, but still very important.

The development of such a process involves a very large amount of experimentation and development of experience, both in methods of construction and the proportioning of boilers, condensers and the auxiliary apparatus.

It has now been in process of development for about ten years, with still much to be done.

Cutting Tools

An old college professor once remarked, in commenting on the problems awaiting solution, that the nearer we approach the light the greater the surrounding darkness.

The elaborate report on the present status and future problems of the art of cutting and forming metals that was presented at the December meeting of the American Society of Mechanical Engineers, would lead one, at first glance, to assume, that here at least was one thing that had been so thoroughly investigated that the end was in sight. But, a careful reading of the report leaves one almost breathless with the thought that in spite of all we know and all we have done, there is so much to be learned that we seem to have done but very little.

The committee who have charge of this subject is a large one and includes representatives of all the groups that have been at work on the various phases of the problem, and ask that any, who can do so, will send in whatever information may be acquired. Detailed research is, of course, the best means of acquiring this knowledge but throughout the railroad shops of the country there is a vast mass of new conditions constantly arising which must be met. A statement of these conditions coupled with one as to the solution of the problem will be of value to the committee and railroad officials and employes are thus in a position to assist very materially in the work.

For example, the lubrication of the tool is a matter of vital importance. In 1895 Prof. Kingsbury found that a crack always preceded the point of the cutting tool, and that this crack develops in the direction of the circumference of the finished work below the tool, and so forms the actual surface of the final work except when the tool is very dull, in which case this surface is rubbed by the tool itself.

This circumferential crack which goes in advance of the cutting edge develops in a straight line for a certain distance and then turns off at 45 degrees with the original direction, branching out towards the surface of the chip, thus permitting the chip to unwind from the stock and slide out along the top of the tool. Immediately afterward a new crack is developed again in the circumferential direction, forming the next segment ot the finished cut. These segments are recognizable in the ordinary cross-banded finish of the work as left by the cutting off tool. The better the lubrication, the narrower are these bands.

In order to work properly the lubricant must get in between the chip and the top of the tool. This it does by being sucked into the crack, above the tool by the partial vacuum created when the crack first opens; then the lubricant by adhering to the under side of the chip serves to lubricate the passage of the chip over the top of the tool. It is at this point, namely on the top of the tool, that the greatest friction of the chip takes place, and the properties of the lubricant must be such as to enable it to reach this surface.

With a very viscous lubricant, or with a wide cut or with a high speed the lubricant does not find its way in quickly enough, and under such conditions it is common practice to use some very thin lubricant such as soda water, a thin emulsion or other non-viscous cutting fluid.

It is well known that the viscosity of lubricants varies with temperature and pressure, and here we are confronted with the problem of making an allowance for a change of viscosity because of a change in temperature and pressure. To do this requires a determination of the temperatures existing at the point of the tool. The pressures probably rise to 100,000 lbs. per sq. in. and, when cutting with high speed steel, the red heat developed shows that the temperatures must, at times, rise to several hundred degrees.

Experiments have been made for the determination of the viscosities of lubricants and different temperatures and pressures, from which it appears that lard oil remains exceedingly fluid at higher pressures than any other thus far tested, and this fact may be in agreement with the common experience regarding the superiority of lard oil for cutting steel at moderate or low speeds. Most oils become exceedingly viscous or else suddenly plastic at certain critical pressures.

It may be that these oils which become plastic or solid at low pressure are unsuitable for cutting tools and that the viscosity experiments may give us a clue to fluids having desirable properties as cutting tool lubricants.

The committee recommends that further work be done in order to determine as to what correlation there may exist between the viscous or plastic properties of lubricants under pressure on the one hand, and their suitability as cutting-tool lubricants on the other hand. The above suggestion pictures the mechanism of lubrication under the chip as follows:

When a mineral oil adhering to the lower surface of the chip is dragged into the place where pressure begins to develop, it solidifies and creates excessive friction. The lard oil, on the contrary, may possess just the right viscosity under pressure to serve effectivly as a lubricant. It is evident that an oil would fail to give satisfactory lubrication under the chip, after having reached that spot, if the resulting combination of pressure and temperature should make it either excessively viscous (or plastic), or excessively fluid.

To secure actual knowledge on this matter will require two lines of research: First, the measurement of viscosity of all lubricants under extreme pressures and temperatures; and second, determination of the actual temperatures and pressures existing under the chip of the cutting operation.

The magnitude of this one point gives some idea of what lies before the committee in its investigation into all the details that enter into a thorough understanding of the problems entering into the cutting of metals.

Locomotive Lubrication

To the Editor:

I have read with a great deal of interest the article entitled, "A New Language for the Steam Locomotive," which appeared in your issue for November. The chart published in connection with the article referred to is highly interesting and a study of it should prove of value to those who have to deal with the issues involved in a consideration of the general problems of railways.

I fully agree with your interpretation of the importance of the lubrication question, and that the subject has not had the attention it deserves. It is an accepted axiom that a poorly or improperly lubricated machine never give good results, and it is my experience that lubrication problems are handled by a rule of thumb or cut and try methods so far as the locomotive is concerned. The increase in size and capacity of equipment means, of course, more surface or square inches to be lubricated, which was so well brought out in the chart you published. This measure of service is augmented by the increased weight per square inch of projected area and higher rates of speed, so that the ultimate demand which must be met by the lubricant is one of no small importance.

That derailments, hot boxes, etc., that interfere more or less with train operation and increase the cost of maintenance, can contribute something to this lubricating question, I submit a brief review of results obtained in the successful treatment of hot driving boxes on large freight engines on one of the heavy coal carrying lines operating in a mountainous country under what might be termed very severe or heavy working conditions. This company had experienced considerable trouble and expense in connection with hot driving boxes on this class of power. Figuring on a basis of the square inches of surface lubricated and the cost during the most troublesome period, it was about as follows:

Number square inches rubbing surface lubricated with one pound of grease..	26,295,759
Cost of driving box compound per 100 miles run	$1.44

Certain remedial measures were adopted through the cordial co-operation of the officers of the railway company and the oil company from whom lubricants were purchased which resulted in the foollowing improvement in service and cost:

Number square inches rubbing surface lubricated with one pound of driving box grease	44,598,285
Cost of driving box compound per 100 miles run	85c.

Here is an improvement of more than 60 per cent in miles, cost and service rendered, while the money value of relief from delays due to hot bearings would be difficult to estimate. The results show very plainly what can be accomplished in the solution of problems of this kind.

Another somewhat similar comparison came to my notice with respect to relative mileage made and costs of valve and cylinder lubrication as between two types of lubricators on one of the leading trunk lines in the Northwest. The hydrostatic lubricator was generally used on this line, with the usual methods of lubrication. The average miles to one pint of valve oil on all power was less than 40, while passenger engines averaged around 50, and the average life of the cylinder packing rings was less than 20,000 miles.

Some new Pacific type passenger engines were purchased and placed in service that were equipped with force feed lubricators in which the amount of lubricant was predetermined, and could not be changed by the crew.

As a result, these engines easily made an average of 80 miles to a pint of valve oil, the life of cylinder packing rings was increased to as high as 90,000 miles and the cylinders and valves were in better condition than those of the engines equipped with the other type of lubricator.

The rubbing surfaces of the valves and cylinders of these engines would be about 173,600,000 sq. in., in 80 miles, and on the basis of this distance to the pint of oil, the square inches lubricated for one cent would be 27,776,000. I do not suggest either of these cases as an indication that the quantity of oil should be reduced all around, for while there is waste to be found in some cases, there is none in others. What is most needed is a more scientific, mechanically correct method of determining the quality and quantity of lubricants for the different classes of service and parts of locomotives and also some equally good rules or standards of procedure in methods of their application.

Consulting Engineer.

New York City, January 25th, 1924.

Economy in the Use of Fuel

Among the organizations that have taken an active part in the general question of the conservation of fuel is the Engineers' Club of Philadelphia, at whose rooms there was held a most interesting meeting on January 15, 1924. Prof. R. H. Fernald, President of the Club, presided.

Among those that contributed papers or discussions under the general title of Railroads were:

Mr. George Gibbs, Consulting Engineer, New York.

Prof. E. C. Schmidt, University of Illinois, Urbana, Ill.

G. M. Basford, Consulting Engineer, New York.

W. G. Besler, President, C. R.R. of N. J., New York.

R. M. Smith, Pennsylvania Railroad.

Max Toltz, Consulting Engineer, St. Paul, Minn.

B. T. Converse, Baldwin Locomotive Works, Philadelphia.

Charles P. Dampman, Supervisor Fuel Conservation, P. & R.

V. L. Jones, Asst. Mech. Engineer, N. Y., N. H. & H. R.R., New Haven, Conn.

J. Keller, Supt. Fuel Department, Lehigh Valley R.R.

W. E. Symons, Associate Editor, Railway and Locomotvei Engineering, and Chairman of the Committee on Fuel Conservation of the Traveling Engineer's Association

Also representatives from the New York Central Railroad, Virginian Railway, Delaware & Hudson Co., Chesapeake & Ohio Railway, and Delaware, Lackawanna & Western Railroad.

The first paper was by Mr. G. M. Basford, and the discussion following its presentation was of much importance to railway men. It dealt with locomotive development, fuel economy and locomotive efficiency in general. Mr. Basford pointed out clearly how existing engines could be vitalized by the use of improved devices such as booster, superheater, feed-water heater, brick arch, etc., using graphic charts as supporting data, the increased efficiency making it possible for two engines to do the work formerly requiring three. He cited a most striking example of improvement in locomotive design wherein a modern engine that could handle 10,000 tons in one direction over the line, could on the return trip take 4,000 tons just ahead of a passenger train scheduled at 49 miles per hour, which shows a wide range of flexibility.

Mr. Basford predicted still greater improvements in the steam locomotive, mentioning higher steam pressure. He also referred to the stand-by losses in fuel, which on one line was reported to be 30 per cent and should be reduced.

Prof. Schmidt of University of Illinois spoke favoring improved devices for saving fuel and a more scientific plan of procedure.

Mr. Smith of the Pennsylvania Railroad read a very interesting paper on the possibilities of saving 15 to 25 per cent in fuel by improved designs, devices and methods.

Mr. Dampman of the Philadelphia & Reading read a paper in which he detailed methods of procedure on their line which is very systematic, and brings good results. A most interesting point was brought out by Mr. Dampman as follows:

That in 1919 there was mined, sold to the railways, hauled over their lines, handled to coal chutes, delivered to engine tenders, delivered to the fire box either by power stoker or manual labor and finally handled into and out of the ash pit, Many Million Tons of Non-Combustibles, such as rock, slate, common real estate, etc. This one feature alone should be sufficient to arouse to activity all those who have to do with economy in fuel, for when we make a low estimate of the millions of dollars here thrown away, as it were, in labor, use of cars and other facilities, loss in freight revenue, plus the decreased efficiency of locomotives, the figures are astounding and justify drastic action. Mr. Dampman also pointed out that on a division with 100 engines under average conditions, there could be a saving effected of about $90,000 per year in stand-by losses, firing up, and bringing engines into terminals with light fires, etc.

Mr. Keller of Lehigh Valley Railroad gave a good talk on fuel economy, but felt that much improvement should be made in bookkeeping, preparing records, etc. He reported that engineers and firemen on his lines are keenly interested in fuel economy, even to the extent of requesting that careful check be kept their individual fuel records so as to properly credit those who are proficient, and thereby stimulate others to improve. A cash prize or bonus is recommended to maintain a friendly rivalry among engineers and firemen to head the list with the best fuel records.

Mr. Peoples spoke on advantages of powdered coal for locomotives, handling the subject in a most able manner; among other features he pointed out that the stand-by losses were now estimated at about 17,000,000 tons of coal per year and the saving on this item plus the greater saving on the line could easily reach 23,000,000 tons of coal per year with pulverized fuel. At this point the question of feasibility of internal combustion engines for locomotives and electrification was raised, to which Mr. Basford responded, explaining why the electric locomotive had a special field while the steam engine's was not so limited.

In the matter of Diesel engines, W. E. Symons, Associate Editor of Railway and Locomotive Engineering, referred to plans of Mr. Elmer Sperry, and also that a new design of locomotive was now under construction in England, with 8 cylinders using steam on one side of the pistons and internal combustion on the other, but expressed the belief that the steam locomotive was in no danger of being displaced in its leadership. Mr. Symons also pointed out that economies could and should be brought about through longer runs and longer hours of service of locomotives, the average actual running time now employed in earning revenue is about 5½ hours in 24, or about 23 per cent. of time, which is too low and represents a great waste in idle capital, the stand-by fuel losses are too high and should be corrected.

Mr. Morris L. Cooke read a most interesting paper on Public Utility Centralization, Giant-Power Survey, etc., which was followed by others, particularly powdered fuel in power houses, carbonization of coal, by-products, etc., these papers and discussions were all high class and interesting, but of course not directly applicative to the question of locomotive fuel economy.

In his paper Mr. Cooke stated:

There is in five (5) different counties in western Pennsylvania a sufficient known quantity of coal in each county to equal the water power of Niagara Falls for many hundreds of years. So that no apprehension need be felt as to the immediate necessity of utilizing water power—coal is King and will be for many years.

It was also stated that more than 40,000,000 tons of coal is burned in Pennsylvania for power per year from which no by-products are secured.

Railway Taxes Pass a "Million Dollars a Day"

The statistics of the Interstate Commerce Commission for November, 1923, which recently have become available, disclose that in that month the tax accruals of the Class I railways amounted to $30,386,092, or $1,012,870 a day.

This was the first month in history when the tax accruals of the railways exceeded a million dollars a day.

The increase in railway taxes is seen in the following statistics giving the tax accruals in November of each of the last six years:

1918	$15,910,000
1919	$18,820,000
1920	$22,343,000
1921	$25,042,000
1922	$27,284,000
1923	$30,386,000

Since 1919 the taxes paid by the railways have regularly exceeded the cash dividends paid by them. In 1922 the taxes of the Class I roads exceeded their dividends by about $34,000,000.

The total taxes of these roads for 1923 are estimated at over $330,000,000, and if they continue to increase in 1924 as they did in 1923, they will amount this year to approximately $365,000,000. This would exceed the dividends paid by these roads in any year since 1914 and would be equivalent to a dividend of 5 per cent on all their outstanding stock.

197,875 Freight Cars and 4,037 Locomotives Installed Last Year

The railroads in 1923 placed in service 197,875 new freight cars as well as 4,037 new locomotives, according to reports filed by carriers with the Car Service Division of the American Railway Association.

Of the total number new coal cars numbered 83,296 and new box cars 78,711. They also installed during the year 22,078 new refrigerator cars.

Reports also showed that on January 1, 1924, the railroads of the United States had 25,619 new freight cars on order with deliveries being made daily. New cars on order included 10,128 box cars, 9,990 coal cars, 1,790 refrigerator cars and 3,017 stock cars. At the beginning of this year 510 new locomotives were on order.

Conservation of Fuel in Railway Operation

By W. E. Symons

Of the various items that go to make up the total operating expenses of our railways that of fuel is the largest single item, the amount paid out on this account last year was more than $523,000,000 or over 11 per cent of the total operating expenses.

Much has been written and said on the subject of economy in the use of fuel, and while progress has been made both as to methods of handling and firing, and thousands of new and old locomotives are equipped with fuel saving devices, yet there is still room for greater economies in many ways.

The trend of human thought moves in cycles, in social, civic, political, industrial, financial and economic questions, and this is particularly true with respect to railway development and operating efficiency. In fact our angle of vision is sometimes such that at times the neutral observer can plainly see that there are some who are straining their eyesight in an effort to locate *nickels* while actually stumbling over *five dollar bills.* Thus they go on until awakened to the fact that the same or even a less expenditure of funds and energy in some other direction might have yielded a much greater return.

In considering the economic feature of any item of expense in railway operation it is customary to do this by comparison with former periods on the same and other lines, and while this is helpful, it must be used with due consideration for wholly different operating conditions, seasonal changes in traffic, etc., and unless this is done, one may be led into *serious error.* In the matter of fuel economy many comparisons are both instructive and helpful in effecting improvements, while certain others are merely indicative of favorable or unfavorable operating conditions on a certain line or territory. Therefore it may be, and sometimes is, true that a line with relatively low engine miles per day and high cost of fuel per 1,000 gross ton miles of freight or passenger car miles, is as efficiently managed as one with a much better showing on paper.

Railways and Mileage			Average number of engines on line daily			Statistics - Freight						Passenger			Cost of Coal Per Ton	Ratio of Coat of Fuel to Operating Expenses	Ratio Operating Expenses to Earnings
	Railways	Mileage	Serviceable	Not Serviceable	Stored	Gr. Tons per train excluding engine & tender	Net Tons per train	Net tons per loaded car	Car Miles Per Day	Eng. Miles Per Eng. Day	Lbs. Coal 1,000 Gr. Ton Miles Including Eng. & Tend.	Pass. Train Cars Per Train	Eng. Miles Per Eng. Day	Lbs. Coal Per Pass. Train Car Mile			
1	Santa Fe	9,905	804	177	45	1,683	572	19.6	45.9	73.5	145	7.9	128.1	15.7	$3.65	11.0	73.9
2	C. & N. W.	8,463	871	197	57	1,327	566	24.9	25.6	53.7	161	6.3	102.6	20.6	$3.48	10.2	81.6
3	C. M. & St. P.	10,991	950	175	91	1,473	662	25.4	29.5	55.4	156	6.0	105.5	17.3	$4.10	10.2	82.6
4	Gt. Northern	8,251	653	108	53	1,791	805	27.9	30.8	55.6	142	6.1	100.1	16.5	$5.40	15.0	77.0
5	Nor. Pacific	6,415	582	152	41	1,718	758	26.2	31.3	49.4	131	6.7	82.6	16.6	$4.68	11.6	75.6
6	C. B. & Q.	9,338	810	200	24	1,612	727	26.9	34.5	62.	176	6.5	112.3	16.7	$3.72	10.8	76.9
7	Rock Island	7,635	539	204	5	1,239	534	23.6	30.1	70.9	180	5.8	109.6	20.5	$4.09	12.0	80.3
8	Alton	1,010	125	32	12	1,425	613	26.2	28.8	76.	163	6.1	114.2	18.0	$3.36	9.4	85.7
9	D. & R. G.	2,593	268	77	20	1,174	536	25.9	18.6	48.2	254	6.9	71.2	20.2	$2.96	8.4	78.9
10	Sou. Pac. P-S.	6,942	652	140	5	1,671	672	23.3	44.8	82.3	148	8.0	140.5	12.4	?	10.5	69.5
11	Union Pacific	3,709	509	64	91	1,805	672	22.0	78.4	89.0	148	8.2	165.2	14.0	$3.39	10.7	68.6
12	Mo. Pacific	7,305	451	161	--	1,401	631	24.9	30.5	70.	159	5.7	134.7	17.8	$3.63	9.0	84.7
13	Tex. Pacific	1,953	173	31	13	1,297	534	22.3	27.4	52.6	153	6.7	117.7	15.1	$4.97	8.9	81.2
14	Sou. Pac. A-S.	3,710	237	58	7	1,296	576	24.7	30.9	80.6	130	7.0	155.6	12.4	$5.47	8.7	85.0
15	New Haven	1,974	302	75	7	1,231	519	21.1	15.6	51.2	169	6.5	92.0	20.0	$6.36	9.2	81.1
16	Del. & Hudson	993	252	47	43	1,770	914	33.0	32.9	64.0	205	5.3	80.4	24.9	$3.79	9.8	94.7
17	Erie	2,309	664	138	91	2,089	939	26.7	39.3	53.7	139	7.8	88.2	18.1	$4.45	10.7	93.7
18	Leh. Valley	1,317	419	111	19	1,723	822	29.2	29.1	52.9	176	7.7	89.6	19.1	$5.04	11.8	94.6
19	Mich. Cent.	1,827	328	61	42	1,621	646	21.0	31.3	54.9	138	8.9	137.2	12.6	$5.35	10.7	71.4
20	N. Y. Cent.	6,469	1,328	358	322	2,118	920	26.4	29.8	54.1	129	8.2	108.1	13.6	$4.47	9.2	80.0
21	Wabash	2,418	286	49	---	1,512	630	22.2	38.5	77.3	159	5.8	148.1	16.8	$3.57	8.8	83.3
22	B. & O.	5,212	1,080	202	129	1,719	835	30.5	28.0	65.9	190	6.7	138.5	19.2	$3.24	9.3	82.2
23	Penn. Sys.	10,906	2,966	552	257	1,756	865	32.4	23.0	53.1	156	6.8	111.2	19.2	$3.55	7.5	82.6
24	P. & R.	1,117	319	113	36	1,672	872	34.1	23.9	60.9	189	4.7	70.7	30.2	$4.45	11.2	75.7
25	C. & O.	2,553	424	106	11	2,224	1,196	41.9	40.2	69.7	139	5.6	108.5	21.8	$3.60	9.7	79.2
26	Nor. & West.	2,228	531	147	46	2,183	1,164	40.2	33.3	52.5	201	6.5	109.4	25.6	$2.31	6.6	75.3
27	A. C. L.	4,861	370	64	40	1,288	506	20.0	31.6	62.	133	7.2	99.3	14.0	$4.23	10.0	73.5
28	Ill. Cent.	6,190	761	127	--	1,712	756	28.3	40.2	75.	152	6.0	125.0	19.7	$3.16	9.2	77.8
29	L. & N.	5,032	615	86	--	1,179	571	31.4	28.5	91.2	177	5.9	141.7	20.7	$2.59	7.4	82.2
30	Southern	6,942	813	134	4	1,191	514	22.5	27.5	56.5	198	6.2	107.6	20.2	$3.09	9.9	75.6
Totals & Averages		150,568	19,072	4,146	1,511	1,580	717	26.8	32.6	63.8	163.2	6.49	113.1	18.3	$4.00	9.9	80.1
Averages in U. S.						1,542	717	27.9	28.0		160.0	6.49	108.6	18.0	$3.94		82.7

STATISTICAL ITEMS OF 30 STEAM RAILWAYS

Mileage—Motive Power—Freight Tonnage and Economy in Handling Freight and Passenger Trains

Statistical Items of 30 Steam Railways

With the foregoing warning as to the danger of passing judgment without a full knowledge of all conditions, the table of comparisons is offered for study as it contains much food for thought on the subject.

In the item of pounds of coal per 1,000 gross ton miles of freight, and by disregarding the Denver & Rio Grande with the extreme in mountainous mileage, the record of certain other lines that cross one or two mountain ranges is such as to serve as reminder or mild rebuke to other long-haul lines with almost wholly level track or water grades to operate against.

The average for all lines is 163.2 lbs. per 1,000 gross ton miles which includes three lines that are above 200 lbs.

but with certain lines largely in a mountainous country below 150 lbs. It seems only reasonable to assume that there is an inviting field for missionary work in bringing some of the records of lines in more favorable territory, down to or below this record and thereby save several *million dollars* on the fuel bill.

It will be observed there is a close relation between average freight car miles per day and the pounds of coal per 1,000 gross ton miles, and this in a measure reflects the character of business handled, the transcontinental lines reaching to the Pacific coast, all have a high car mileage per day, notwithstanding their lines are in mountainous country, their business, however, is principally through long haul traffic, while such lines as the New Haven, which might be termed a combination of (a) Receiving or gathering line; (b) Delivering line, and (c) General switching or serving line, only gets 15.6 miles per car per day, and the pounds of coal per 1,000 gross ton miles is far in excess of the Santa Fe, Great Northern, Northern Pacific or Southern Pacific, for the simple and obvious reason that fuel on the New Haven is largely used switching, stopping and starting local trains, etc., while with the other lines mentioned it is used to produce transportation or mileage.

Similar comments may be made on the passenger train statistics in which it will be observed that the number of cars per train, the locomotive miles per day and the pounds of coal per passenger car mile, in the same territory, bear a close relationship. One striking exception to this, however, is the D. & R. G. with the worst or extreme mountainous conditions to cope with and only two pounds of coal per car mile above the average of 30 lines, and many pounds below most of the lines far better situated. There is room for much economy here. In fact, millions may be saved for a mere fraction of expense involved in the saving.

Cost of Fuel and Its Relation to Operating Expenses

It will be observed that there is quite a wide range in the cost of fuel used by our railways which is obviously influenced more or less by geographical location.

Engine mileage is an important factor in the question of fuel economy and while this is clearly reflected in the tabulation, it will be observed that there is a range of from 48.2 miles per day to 91.2 or more than 108 per cent in freight service and from 70.7 to 165.2 or about 233 per cent in passenger, the lines of extreme high and low mileage both being in the Rocky Mountain country although one is a wholly mountainous line while the other has considerable valley mileage.

Hours of Time in Each Day Under Way Earning Revenue

It is not generally known or fully understood just how comparatively a short portion of each 24 hours locomotives are actually under way producing revenue, and to make this point clear the following table of hours, miles and speed of freight engine is reproduced from I. C. C. reports.

From the table it is quite clear that freight engines in 1922 were only under way, producing revenue to their owner, 4 hours and 37 minutes, and only 5 hours and 30 minutes in 1923, and while it is quite true they were in service a longer period, possibly close to 8 hours per day, yet *SERVICE* and *TON MILES* is two different things, and what is badly needed is *less* of the *former* and *more* of the *latter*.

The overhead or stand-by losses at terminals and on line of road, runs well into the millions of dollars, to say nothing of the enormous capital investment required to supply power thus handled. That drastic action should be taken is so plain to any student of railway economics as to not permit of discussion.

Table compiled from reports of 161 class roads representing 173 lines with a mileage of 234,529. Period covered 11 months of 1922 and 1923.

District or Territory	1922 Train Speed	1922 Engine Miles Per Day	1922 Hours Running Only	1923 Train Speed	1923 Engine Miles Per Day	1923 Hours Running Only
New England Region	10.9	50.6	4'.36"	10.2	57.3	5'.36"
Great Lakes Region	11.0	46.5	4'.13"	10.6	58.2	5'.30"
Oh., Ind. and Alleg. R'g'n.	9.9	47.4	4'.47"	9.4	59.1	6'.18"
Total Eastern Dist.	10.4	47.3	4'.30"	9.9	58.5	5'.54"
Pocahontas Region	9.9	48.6	4'.54"	9.8	58.4	4'.55"
Southern Region	11.6	59.3	5'.6"	11.5	70.0	6'.36"
North Western Region	11.6	48.7	4'.9"	11.4	55.1	4'.48"
Central Western Region	12.2	57.3	4'.42"	12.2	66.3	5'.25"
South Western Region	11.5	53.2	4'.37"	11.5	58.5	5'.06"
Total Western Dist.	11.8	53.2	4'.30"	11.8	60.5	5'.07"
United States	11.1	51.3	4'.37"	10.9	60.8	5'.30"

Locomotive Improvements

Wonderful strides have been and are still being made in refinement or improvement in design of locomotives, all tending to a higher degree of efficiency in the finished unit.

As heretofore mentioned, however, we sometimes become so engrossed on a certain feature that we are liable to completely overlook others of equal or even greater importance and that is true today with respect of several features of railway development and particularly so as to one important feature of the steam locomotive.

In addition to the great overhead or stand by losses already referred to, and that they will yield to remedial measures, there is the question of negative or back pressure on pistons combined with front end or drafting arrangements that presents equally as inviting a field for:

(a) Increasing the efficiency or hauling capacity of the engine.

(b) Reducing the quantity of fuel used for a given amount of work or service, and

(c) Reduced cost of repairs and longer life to the parts affected.

We have and are still devoting much time, energy and expense to improve and perfect devices that have to do with the conversion of water into steam and for getting the steam from the boiler to the cylinders, but have fallen down quite badly in getting the steam out of the cylinders in as economical a manner.

It might be said that in most cases the exhaust steam is simply permitted to flow out through exhaust passages, nozzle and stack, to the atmosphere with little regard to the amount of back pressure or its retarding effect on the pistons which detracts from the engine's real pulling power and in overcoming which a great loss in fuel is involved.

If an engineer were known to run with brakes slightly stuck he would be called sharply to account and very properly so, but thousands of them run engines every day with unnecessary excessive back pressure on the pistons which is equivalent to slightly stuck brakes, and they are absolutely powerless to furnish any measure of relief although the same could be easily provided and at the same time the direct and indirect saving effected would run into many millions of dollars.

The average cost of fuel for all locomotives per annum is in excess of $9,000, while some engines use twice that amount, yet there are thousands of engines fully equipped with modern devices for effecting economy in various ways, that yield a very slight return on these investments and a much below par service from the complete unit for the simple reason the *"machine is choked up and can't run as it should."*

It is not surprising that railway officers exercise caution in accepting the numerous propositions with which they are beset by the wonderful assortment of railway doctors that have sprung up in the last two decades. Many of their schemes are too visionary to be considered seriously, but may in a measure account for some very important matters, badly in need of attention, being deferred from time to time or overlooked entirely. This should not be the case, however, for an executive or the head of a department should know personally the state of affairs in all matters consigned to his keeping and should correct errors, make necessary improvements, or if need be, clean house without the aid of outside talent.

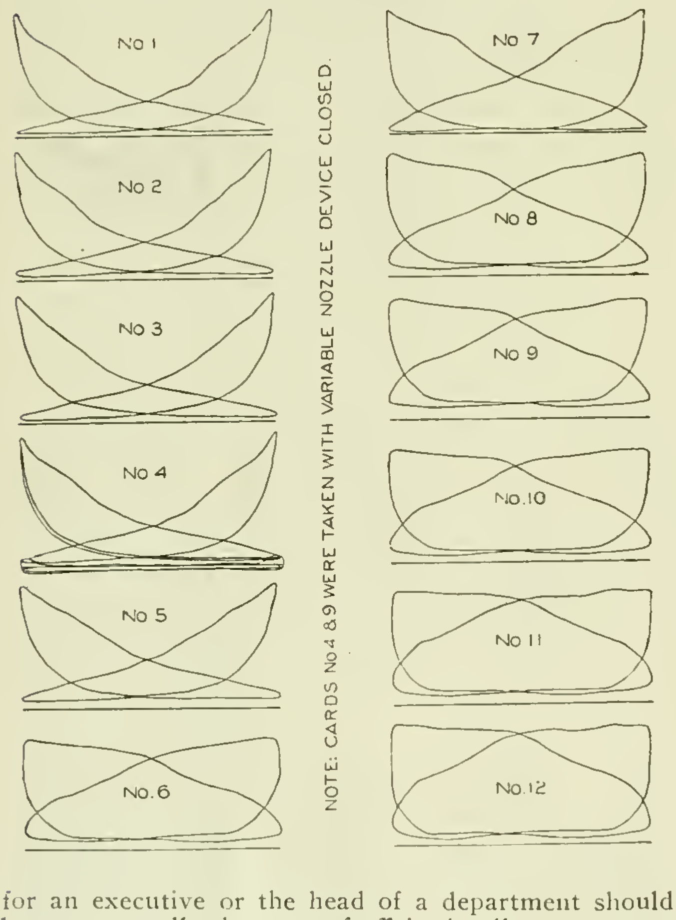
Railway officers are all very busy men, some are so badly behind with ever increasing current affairs that of the multiplicity of things for which they are responsible some are neglected, and there is no single feature of locomotive design or operation, having as great an influence or effect on the efficiency of the machine as a transportation unit, that has been as badly neglected as the exhaust nozzle and its related parts, which have to do with back pressure on pistons.

Much has been written and said on this subject of back pressure on pistons, and while many were wholly theoretical as to conditions and means of improvement, little or no constructive work has been accomplished. The fire box or front end of a locomotive is a poor place to locate or attempt to operate any kind of mechanism affected by high temperatures, for in the former it will burn out and the latter it will suffer from heat, abrasion, and gum up, so that from one or all of these causes failure too often results.

Variable exhaust nozzles, or at least most of them, belong in this latter class and the writer fully concurs in the views of those who seek to *escape the curse* that some of these *contraptions* would surely bring upon any one who stood for them. On the other hand the writer does not believe in running an engine, day, week, month and year in and out with excessive back, pressure on pistons, thus wasting thousands of dol-

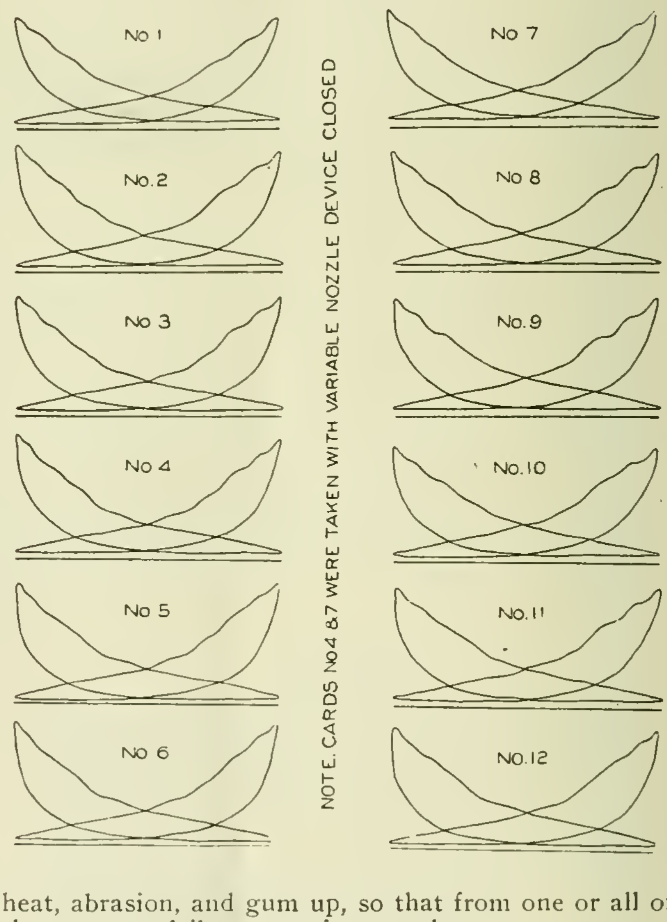
INDICATOR DIAGRAMS FROM PASSENGER LOCOMOTIVE
Weight of engine 115 tons; drivers, 69 inches; piston 19x26; scale of spring, 80.

Card No.	Wt. of train in tons.	Total wt. E. & T. in tons.	Speed per hr. miles.	Rev. per minute.	Boiler press. lbs.	M. E. pressure. Lbs.	I. H. P. of engine.	T. P. per lb. of M. E. P.	Ratio of G. A. to H. S.	Ratio of ext. flue area to f. box area.
1	325	440	47	229	160	42.3	721.28	135.64	1 to 73.25	11.8 to 1
2	"	"	51	249	170	44.0	815.75	"	"	"
3	"	"	59	288	170	43.5	932.86	"	"	"
4	"	"	45	219	170	44.6 c. 48.6 o.	727.30 c. 792.52 o.	"	"	"
5	"	"	60	292	170	51.5	1119.46	"	"	"
6	"	"	30	146	165	94.0	1020.84	"	"	"
7	885	1000	27	132	156	71.9	706.70	"	"	"
8	"	"	37	180	178	92.0	1233.00	"	"	"
9	"	"	30	146	165	94.0	1022.46	"	"	"
10	"	"	27	132	165	98.0	963.24	"	"	"
11	"	"	32	156	160	106.0	1231.30	"	"	"
12	"	"	25	122	170	118.5	1081.25	"	"	"



INDICATOR DIAGRAMS FROM PASSENGER LOCOMOTIVE
Weight of engine 115 tons; drivers, 69 inches; piston 19x26; scale of spring, 80.

Card No.	Wt. of train in tons.	Total wt. E. & T. in tons.	Speed per hr. miles.	Rev. per minute.	Boiler press. lbs.	M. E. pressure. Lbs.	I. H. P. of engine.	T. P. per lb. of M. E. P.	Ratio of G. A. to H. S.	Ratio of ext. flue area to f. box area.
1	325	440	74	361	165	33.3	894.94	135.81	1 to 73.25	11.8 to 1
2	"	"	70	341	170	41.0	1041.25	"	"	"
3	"	"	65	317	165	39.0	920.80	"	"	"
4	"	"	60	292	170	39.0	847.75	"	"	"
5	"	"	60	292	170	42.0	912.92	"	"	"
6	"	"	58	283	170	41.0	860.92	"	"	"
7	375	490	74	361	170	34.0	907.70	"	"	"
8	"	"	74	361	170	38.0	1021.25	"	"	"
9	"	"	74	361	160	38.5	1034.68	"	"	"
10	"	"	73	356	160	38.0	1007.54	"	"	"
11	"	"	70	341	170	39.0	990.50	"	"	"
12	"	"	68	331	170	44.5	1099.00	"	"	"



lars in fuel and actually preventing the engine from doing the work it could do if simply given relief and an opportunity. As a rule medicine don't taste good, and is expensive, but as between dragging one's self around always below par, when a very practical inexpensive remedy is available that will remove your trouble, restore your vigor and increase your capacity and efficiency, the practical man will say, "Give me the medicine."

There are many thousands of locomotives running in the United States with back pressure on pistons which in wasted fuel and decreased capacity combined will in the aggregate amount to many millions of dollars, and if means were provided for nozzle adjustment to suit conditions of service, a large part of this waste could be saved. Until some effective device or methods are actually applied and the results recorded, it cannot be said that conservation of fuel has received or is receiving the attention it deserves.

Theory Versus Facts

To those who may have overlooked this important matter, to those who may look upon it as an economic ill that will not yield to remedial measures, and if perchance there be some who claim there "Ain't no Such Animal," a series of indicator cards are herewith reproduced that were taken from a passenger locomotive about twenty-five years ago, that was equipped with a practical, inexpensive device whereby the engineer could at any time by a simple hand movement change the area of the exhaust orifice from maximum to minimum opening, and thereby increase or decrease the engine's efficiency more than one hundred horse power, and this on an engine that today is considered a very small one.

It will be noted that cards 4 and 7 were taken at 60 and 74 miles per hour with nozzle closed, while cards 5, 6, 8, 9 and 10 were taken with nozzle at maximum opening, thus relieving back pressure from pistons and show from 65 to 127 increased horsepower.

In cards 2 and 4, taken at 45 miles per hour, it will be observed that the difference in back pressure on pistons, even at this short range of cut-off, as shown by the compression line is 65 horsepower. At lower rates of speed it will be noted the excessive back pressure on pistons as shown in card 9, at 30 miles per hour with nozzle closed and in cards 8 and 11, with nozzle open and the excessive pressure removed, show increased horsepower of 209 to 211. The writer does not assume there is any one qualified to properly guard the railway company's interests in matters of this kind but will agree that on engines in the United States of the above size and less, the possible combined economies would easily run into the millions while on the larger power the possibilities are correspondingly greater.

Millions of dollars are now being wasted in fuel on account of excessive back pressure on pistons that could be relieved by the use of some means of controlling the exhaust steam at nozzle tip, and to this sum may be added an equal number of millions on account of the loss of efficiency of the engines and decreased cost of maintenance.

With all of these facts right before our eyes, why do we continue to injure our eyesight looking for nickels while we may be stumbling over five dollar bills?

The hundreds of millions of capital in locomotives, should, as the result of increased mileage and hours of service actually producing revenue ton miles and passenger miles, bring greater return to their owners on investments, and effect a wonderful saving in overhead or stand-by losses. The efficiency of a large percentage of the entire schedule of steam locomotive may be materially improved by elimination of excessive back pressure on pistons. There is millions in it!!

Locomotive Design and Operation on the Pennsylvania Fifty Years Ago

By George L. Fowler

It was along in the early 70's that a new spirit seems to have been inculcated into locomotive design and management.

It is true that by 1874 the locomotive had been developed into a thoroughly reliable and efficient machine. The experimental stage seemed to have been passed and there were certain features which had come to be accepted as standard practice. The development had, however, been by way of the process of trial and error without the application of any very scientific methods of calculation and analysis. Speaking broadly, the method most generally employed, had been to make a part heavier if it were to be made stronger, without any very careful study as to the best distribution of the metal used in order to obtain the maximum strength.

Then, too, the locomotive had become a rather ornate affair. It had been the practice to use a profuseness of mouldings and brass work that was supposed to add to the beauty of the machine and certainly did add very greatly to the amount of work required in order to keep it in a presentable condition.

The main problem confronting the superintendent of motive power of the Pennsylvania Railroad at that time in the locomotive work was to introduce something like a scientific method into locomotive designing as well as an artistic sense that would make the appearance of the machine appropriate to its functions and be in reality a thing of beauty as well as utility. The changes that were made in the outlines, first by the Pennsylvania locomotives, and later in all American locomotives have been due to a great extent of the artistic appreciation of what was proper by Mr. Theodore N. Ely who was superintendent of motive power at that time.

The engine was changed from a receptacle of a mass of mouldings and one might almost say filigree work, to a machine of a quiet outline formed of straight lines and simple curves. This is especially a characteristic feature of the Pennsylvania locomotives by which they are at once recognized in any surrounding and in any place. In this work much is due to the able assistance rendered by Mr. Axel Vogt, the mechanical engineer who went to Altoona in 1874 and who was in charge of the designing of the Pennsylvania locomotives from that time up to the date of his retirement on February 1, 1919, with the exception of the year and a half from May 20, 1882, to November 1, 1883.

Important as this work was from the standpoint of the appearance of the locomotive, it is, of course, overshadowed by that of the proportional designing of the machine, by which the minimum of material should be made to do the maximum of work.

It must be borne in mind, in this connection, that the engineer of the middle seventies did not have the same free hand and wide scope of opportunities that he has today. He was limited not only by the materials available but by the means at hand for handling and working such as he did have. Steel for boiler plates was just coming into use, and it was not only limited in the size and thickness of sheets that could be rolled, but was frequently of uncertain quality. Steel castings were practically unknown, and as for tools, the traveling crane was a novelty, and high speed steel had not yet been dreamed of. So, when we regard the situation from the standpoint of the beginning of the third decade of the twentieth century, it appears as though the whole of the work of the development of the locomotive had then to be done.

In 1874 the standard locomotive on American Railways may be considered to have been the eight wheeled or American type, having four driving wheels and a four-wheeled bogie truck in front, and weighing, without its tender from forty to forty-five tons. The engine was used for both passenger and freight work, though some moguls and consolidations, having six wheels and eight wheels respectively coupled, were coming into use.

The work that the locomotives of the Pennsylvania Railroad were forced to do during the period of the Centennial Exposition led to the adoption of a policy that, later, became almost universal, and which superseded the former engine-for-each-man method of operation. From which it appears that the development of heavy trains has been one of the important things that has been accomplished, especially when coupled with the running of locomotives as many miles as they have been run. In other words, that they should be worn out and new ones bought of other kinds.

Of course, when the proposition was first made of chain ganging or double or triple crewing a locomotive it met with a great deal of opposition, but its commercial soundness was soon demonstrated and the plan was adopted. The whole principle is that of running the locomotive as many miles as it can be run regardless of the numebr of locomotive engineers required to do it.

There were, of course, many things that had to be looked after in the development of a system of this kind. In order that the locomotive should be kept in good condition and not allowed to run down, as happened later on another railroad, there was necessitated the employment of careful inspectors and foremen with arbitary power in the roundhouses, so that the locomotives should not be allowed to go out when they were not in good condition to make their runs. And that this might be effected it was insisted upon that the roundhouse foreman should have arbitary power over the despatcher.

If Tom, Dick and Harry were to operate the same engine over different runs, it was taken for granted that they would not take as much interest in it as if they were each running one engine and were held accountable for it.

This point accepted, inspectors were put in the roundhouses who had such arbitrary power, and their numbers were so increased that the work could be properly done.

Then the roundhouse foreman was able to say that a locomotive was or was not in fit condition to go out on the road, while, at the same time the master mechanics were stimulated to see that the power under their charge was not allowed to decrease in efficiency, for it was only in this way, and by the united action of all concerned that the natural tendency on the part of the enginemen to neglect the machines could be overcome.

Matters have been modified and changed from time to time, but the stand, taken at the outset, was that the locomotive was nothing but an aggregation of iron, steel and brass and that there was no earthly reason why that machine should not run constantly, just as a steamship engine runs, so long as it is in good order, and that it should not be laid up for from twelve to sixteen hours out of twenty-four, while the enginemen who run it are resting. In other words, the working hours of the locomotive had been previously limited by the endurance of the man, while its own endurance was practically unlimited.

Then the argument was raised that it would cost very much more to keep locomotives up, that were run continuously, than would be gained. But that argument proved fallacious from the figures that were presented and the engine of multiple crews became the standard practice. Even the strongest opponents of the idea have come to see that there is no increase in the cost of upkeep of locomotives that are run in that way, while the two-fold advantage is gained of keeping the invested capital at work and of being able to wear the locomotives out, get rid of them and replace them by those of a new design.

But the mere obtaining of more work from each locomotive unit, by an increase of the distance it ran and the time it was at work, was but a partial solution of the problem that was pressing upon railroad managements. This secured a greater output in a given time for the capital invested, than where a man and locomotive ran and were idle together, but it did not decrease the labor charge per mile run, and that could only be done by an increase of the capacity of the unit by which heavier trains could be hauled, with little or no additional charge for labor.

But there was an opportunity for cutting down the cost of locomotive operation by reducing the amount of coal burned. It would appear at first sight as though it would be of special interest to the enginemen especially of the firemen to be as economical of coal as possible, simply for the reason that the less the amount used the less labor to be performed. But this was not the case and it was evident that much more coal was being burned in the locomotives than was needed to do the work. The point was to make it a matter of personal interest for the enginemen to save fuel and that this might be accomplished the system of coal premiums was introduced.

It was started and applied, at first, on the Middle Division in 1874, between Altoona and Harrisburg. A man, a prominent member of the motive power staff, was assigned to work up a premium sheet some time prior to this for different trains, and to do it observers were put on the engines to ascertain the amount of coal that was being burned on each. The method adopted was to assign a given number of pounds of coal per car mile for each of the different runs, this limit being based upon the observation that had been made as to the actual amount that was being consumed. These data sheets were issued in printed form to the men and were posted in the roundhouses and so on. The principal feature of the scheme was the limit that was fixed.

If the engineer's and fireman's record was less than the fixed limit, then the value of coal saved was computed, and one-half of this value was given to them. This amount then appeared on the monthly pay roll of the men as a separate item. No account was taken of the men whose record exceeded the limit, except to call their attention to the fact that they had done so, and they were urged to improve not only their own practice but exceed the premium earned by the other men in the service.

These lists were posted in the roundhouses at the terminals so that each engineman could see what the others were doing. It made little or no difference to those who had no sense of pride in their work, but did have a decided influence upon those who wanted to advance and make the most of themselves.

The premiums sometimes amounted to considerable sums and were eagerly sought for. But it was found that the original limits were so largely in excess of what they should have been, that they were gradually revised downward; still not so far that it was not possible for men to earn a fair sum as a premium. This revision was influenced largely by the introduction of different types of power and cars, and was based on loaded car mileage; five empty cars being considered the same as three loaded ones.

But with the still further development of heavy locomotives and high capacity cars the premiums dropped until they were insignificant and unattractive; so that, after having served an excellent purpose they were at last discontinued, the last one having been paid on April 5, 1905.

Meanwhile before the development of the coal premiums, the motive power department set before itself the task of decreasing the unit cost of hauling trains by increasing the size and capacity of the locomotive as it existed in the later seventies.

Then followed a number of years of steady locomotive development, one of the minor features of which was a rearrangement of the classification of the power of the road. Shortly after Mr. Ely's appointment at Altoona in 1874, a start had been made in the standardization of the locomotives and a classification, using successive letters of the alphabet for the nomenclature, was established. In this each new type of locomotive brought out was given a letter, usually the next following in the aphabet to the one last used. The result was that, after about ten years nearly all of the letters had been used, so rapidly had new types been developed. It also happened that engines of really the same type were indicated by widely separated letters. For example, the A, B, C, G, K, L, M, N, O, and P were all of the American type, having two pair of driving wheels with a four-wheeled truck in front, while the I, R and S classes were consolidations. This multiplication of nomenclature was apt to be confusing, so that in 1897 a new classification was adopted. In this, each type was specified by a letter, and variations were indicated by sub-letters and figures. For example, the American or eight wheeled locomotive is known as the class D, and the classification D1, D2, D2a, etc., indicated variations in dimensions.

Snap Shots—By the Wanderer

"God sends meat and the devil sends cooks," might be assumed to be the text of a recent paper read before the Canadian Engineering Institute. Failures of structures are laid to faulty design, and material is given a fairly clean bill of health. That is very nice. If we could only always place our shortcomings on the back of the other fellow, our lot would be a very comfortable one, until the other fellow tried for the same comfort and we find ourselves burdened with his delinquencies, when it is not quite so pleasant. It is the case of a derailment being caused by track or car according to who is placing the responsibility.

The author claimed that designers should know the limitations of their materials. Very true, but how about the limitations of their stresses? Oh, just work on an ample factor of safety. In short, follow the lead of a certain superintendent of motive power, who, when asked as to how he designed his main rods, replied: "Well I calculate a little and guess a good deal."

It seems as though back of all good designing there must be an accumulation of experience and observation backed by good judgment.

Of course he must know of the limitations of his materials, but that may not tell everything even if he could know.

Who knows, to turn back to the item just referred to, who knows what may be the stresses to which the main rod of a locomotive is subjected. What happens when the drivers slip? What happens at a low joint? What happens in the thousand and one conditions that come and go between every start and stop. As Lord Dundreary would say: "There are some things no fellow can find out," and this seems to be one of them.

We have gone far in the determination of the various stresses to which the several parts of a locomotive are subjected, but there is still much to be learned.

It is a long and interesting road to travel, and the end is well worth reaching, but meanwhile it would seem a little more gracious for the material maker with whom this author is allied, to be willing to assume a portion of the burden of responsibility for failures, rather than shift it to the shoulders of the designer.

It is curious how some engineers or their assistants fail to realize the difference between a mechanical and commercial possibility, just as it is a crying fault of inventors. They think because a thing can be done it ought to be done, regardless of its importance or value. Once in a while a case of the kind bobs up that is ridiculous in its exactions. Here is one:

A manufacturer was putting up some special track work, in which the rails had to be curved. They were bent and then laid out on a long planer bed for examination. In places it was found to be possible to push a shim 1/32 in. thick in between the rail and the planer bed. This was too much, and it was insisted that it should be corrected.

The query is as to what kind of a bed that rail was to be put upon that could not stand for 1/32 in. variation in the height of the bottom of a rail. It must have been a surface plate.

Sometimes there is a requirement in a specification that serves merely as a convenience to the purchaser, and on which the engineer can insist to a finicky way. Thus! A certain road was in the habit of buying special work and having the location for which it was intended painted upon it. Once there was a shipment of a dozen or more pieces and the location of one was not painted upon it. Instead of looking up the location, overlooking the omission, having it marked and letting that end the matter a telegram was sent to the maker, calling attention to the lack of paint and asking what was to be done. He was told to send it back and the marking would be put on, or he could have a man paint on it W 29-165.

Sometimes, especially in government work, the marking seems to be of more importance at times, than the thing itself. Once a number of electric motors were ordered by one of the departments and when they had been delivered several hundred miles from the place of manufacture, it was found that they had been stamped with another symbol than that belonging or referring to the department in question. There was nothing the matter with the motors. They were exactly what had been ordered. But because they had possibly been taken from stock and marked with an X instead of a Y, they were forthwith returned to the maker as not meeting specifications.

The maker said nothing. He simply had the X filed off, the Y stamped on and the motors returned, when they were accepted without question.

The query arises as to why some department official did not assume the initiative and do the filing and stamping, if it had to be done, without subjecting the manufacturer to the expense of to and fro expense charges, and the department to the delay of waiting for the to and fro movement? But official red tape puts a halt on everything until the man higher up orders it.

It is a good rule to put employes on their mettle and encourage them to go ahead and get results, even if red tape is broken or frazzled into bits.

A writer in a recent *Atlantic* illustrates Japanese red tape and British and American efficiency at the time of the earthquake. He states that "the hopeless incompetence of officialdom was almost criminal." The British admiral had practically assumed command in Yokohama harbor "and this, defiantly, under the eyes of a powerful squadron of Japanese vessels lying, virtually inactive, in Yokohama Bay."

" 'Why don't you employ some of these ships?' I asked a Japanese officer, pointing at the dozen of war vessels, some of them large cruisers, lying right at hand.

"He looked at them wistfully. 'I wish we might.' He shrugged his shoulders. 'But we can't do it without orders from the Admiralty.'

"And while they were awaiting orders from the Admiralty, the British and Americans had come from China and transported the refugees, and were now threading their way between the motionless warships, bringing ton upon ton of supplies to the stricken city."

Absurd, but are we so altogether without sin that we can cast the first stone?

The men who have lived in Europe, not the four-minute congressmen and tourists who have been shown around so that they could make favorable reports, but the men who have lived in Europe until they knew, and come back to write about conditions have been unanimous in condemning the course of Stinnes and other industrialists for their rapacity, mendacity and betrayal of their country. It is the same old story of contempt for the traitor. Benedict Arnold's reputation does not improve with age.

Elbert Hubbard once wrote a monograph on loyalty, in which he said to the employe: "If you are working for a man, for heaven's sake work *for* him and not against him." A mere echo of the general sentiment that commends loyalty and condemns the knifing of a friend in the back, for loyalty is regarded as a necessary virtue in those occupying positions of confidence or responsibility.

The railroads are having a hard time of it. It is very easy for muckrakers to stir up a grievance and the public is only too ready to lend an ear to evil report. Reckless extravagance is an accusation so easily made that it is small wonder it has been repeated as often as it has, since Louis Brandeis made his famous charge of a million dollars a day daily waste a few years ago, but which he has not yet shown how to avoid.

Charges of this sort were so rampant a few years ago, that it became advisable to organize the Railway Business Association for the purpose, in part, of sustaining the railroads and educating the public into a proper attitude towards the problems of transportation, and it numbers among its members a very many of the prominent firms engaged in the railway supply business. It would be expected that a membership in this association would imply loyalty not only to the association itself, but a two-fold obligation to serve the railroads and refrain from any action that could injure their reputation or credit. Is this obligation always met, or are there some who would sacrifice the reputation of the railroads whom they serve for private gain? The temptation to profiteer is strong.

Some months ago there was published, under the signature of a professional writer, in a magazine having a circulation of about a million copies, an article constituting a spread-eagle arraignment of the railroads on the ground of general inefficiency and disregard of means of effecting savings and insuring safety, which the writer led his readers to infer were in use about all over the world except in the United States, where they were almost wholly disregarded.

The article cited device after device that had been originated in the United States, though he did not give us credit for it, and whose use, we all know is confined almost solely to this country, and implied where he did not directly state it that Europe was teeming with their applications. It was flamboyant, misleading, almost vituperative. That was bad enough. But when questioned the author refused to give the sources from which he had drawn his misinformation. The whole thing had a suspicious look because every one with a single exception of the devices to which attention was called, and which the railroads were arraigned for not using, was made and exploited by a group of companies under single control and having a common missionary in the field. With the single exception, no one else's device had attracted the attention of this reformer, yet he was abnormally well posted as to what this concern was putting out. The coincidence of the refusal to divulge his source of misinformation, coupled with peculiar exclusion of all devices outside of those cited, led some of us to wonder, whether there was not a connection between the two and whether the temptation to exploit the railroads by misrepresentation for the benefit of their own pockets was not too much for these gentlemen to resist. Of course, no one outside will ever know but, the coincidence is passing strange to say the least. And it is a pity, if it has led to false conclusions, that even this trace of a suspicion should have been put upon Cæsar's wife.

I have sometimes been led to wonder whether it would be possible to construct a steam gauge with a Bourdon spring that was accurate throughout the whole range of the circle. They can, however, be adjusted to accuracy at the working point, but not above or below it at the same time. For working purposes this is sufficient, but when an engine is to be tested under varying conditions something better is to be desired. It is more than probable that some of the queer results obtained in engine tests where varying pressures were employed were not queer at all, but due to the inaccuracy of pressure gauge. They are like the idiosyncrasies of chimney draft reported in a paper read before the American Society of Mechanical engineers, some time ago, wherein it was shown that certain chimneys had acted most erratically, but when the discussion was called it appeared that the chimneys were behaving in the most orthodox manner possible and that the author had merely been ignorant of the law of such structures as formulated by Rankine.

The Place of Railway Transportation in Industry

Report of National Transportation Institute Shows Growth and General Efficiency of the Roads

The National Transportation Institute of Chicago has issued its first report in which it makes a statistical comparison between the growth and efficiency of railroad transportation and the three other major industries of the country, namely: agriculture, manufacturing and mining.

The first comparison shows the gain in the number of persons employed between 1900 and 1920. Expressed in percentages these figures show a net gain of 4.28 per cent in agriculture; of 107.67 per cent in manufacturing, of 70.32 per cent in mining and 99.75 per cent in railroads; showing that the percentage increase in railroad personnel stood second in the list.

During this same period there was a revolution in prices and wages. Prices rose steadily from 1900 to 1910. Thereafter they remained relatively stable until 1915. At the beginning of the following year they began to rise once more, until, in 1920, they stood at a point almost three times as high as in 1900. In September, 1923, they were still 90 per cent higher than twenty-three years earlier. Wages rose until they were more than three times as high in 1920. In 1923 they are still almost three times as high as they had been in 1900.

From a review of the relation between the value of the output of the three industries and the amount paid out in freight, it appears that 6 per cent of the food and clothing which we produce, of the iron, steel and coal, of the houses which are built and of the personal services which are rendered, is devoted to the support of the people who transport the products of field, forest, and mine to the point of manufacture; and who carry the products of our factories back to the consumer.

The advantage which the nation derives from the transportation function rendered by the railroads in return for freight rates is the increased production per worker and per unit of capital employed which results from the geographical division of industry. Because of transportation we are enabled to produce commodities at the points where the output per worker and per unit of machinery and equipment is the largest. Fertile valleys and auspicious climatic conditions are of little use until transportation facilities are provided to carry the products to the point of consumption. Lumber is cut from the rich stores of our natural forests. In the absence of railroads, it would be necessary to procure it from expensive reforestated areas near our cities. Tropical fruits and vegetables come from areas where nature supplies the heat and the equability of climate which would otherwise be obtained only under glass and with artificial heat. For the service thus rendered and for the advantages in production which flow from the geographical division of industry, 6 per cent of the resulting product is paid to the labor and capital engaged either directly or indirectly in transporting commodities by rail.

Modern industry has been carried on so long under this plan of geographically localized production that it is impossible to say how much larger our output is at present than it would be in the absence of transportation. But it is certainly many times the sum which we pay to the railroads in freight and passenger rates. This manner of regarding the matter is fundamental to a consideration of the transportation problem. It is easy to forget that transportation is the function which has made possible the unprecedented productivity of modern industrial society. It is well, therefore, to state clearly just what the burden of freight rates comes to in terms of goods and services. In this manner we are able to see clearly that those who are engaged in transporting commodities by freight receive only a small portion of the additional output which is made possible by the geographical distribution of industry. Transportation is an indispensable factor in our modern industrial society.

But it is not necessary to argue the productive nature of transportation. It is a permanent and abiding part of our industrial structure, and will remain so. What we wish to know is whether it has been less efficient in the utilization of the labor and capital which have been put at its disposal to use in transporting products than the industries which have produced them. Our economic situation has changed so rapidly during the last twenty years that it has not been easy to follow the relative position and functioning of transportation which ministers to every phase of our national economic life.

The census shows that almost exactly one-half of our people live in the northeast corner of the United States, which lies east of the Mississippi River and north of the Ohio and Potomac.

The old principle that proximity to markets contributes greatly to the value of land has been in considerable degree offset by the development of railroads. While 24 per cent of the acreage of improved land in farms is situated in this densely populated northeastern section of the country, the value of all land exclusive of buildings and other improvements in this section is only 26 per cent of all farm land in the United States.

The value of improved land in this densely populated section is, therefore, only slightly above the average of farm land in the whole country. Texas, which stands at the other extreme, contains 12 per cent of all land in farms and 6.2 per cent of all improved land in farms. The value of farm lands in Texas, exclusive of buildings, is 6 per cent of the total value of such land in the United States. Iowa contains 5.6 per cent of all improved land in farms in the country. The value of its farm lands is 12.2 per cent of all such land values in the United States.

It is obvious that no such values for this land could exist at points so far distant from the consuming center of the country without our present-day system of transportation.

We have seen the ratio of increase in the numbers engaged in the four industries in 20 years. The following table shows the increase in output and the relative output per person.

Industry	Per cent 1920 to 1900: Persons	Output	Relative output per person
Agriculture	104	138	133
Manufactures***	208	228	110
Mines***	170	221	136
Railroads	199	234*	118*
Railroads	...	292**	147**

*Output measured in tons originating.
**Output measured in revenue ton miles.
***Figures are for 1899 and 1919.

This shows that, in the case of revenue ton miles, which is the real measure of railroad efficiency, that industry leads all the others in the output per person.

The increase in productive output in our three major industries—agriculture, manufactures, and mines—has brought with it a growth in transportation which was even greater than the increase in production of physical goods. For every one hundred tons of freight transported in 1900, we transported 234 in 1920. And where each ton had been transported 242 miles on the average in 1900, it was transported 304 miles in 1920, an increase of 25 per cent. Because of this greater distance, the revenue tons transported one mile were 292 per cent of those carried two decades earlier. The passengers carried one mile increased in the same ratio. The volume of transportation service rendered has, therefore, surpassed the growth of production in the other industries.

In regard to the capital account it has been found that in the case of manufactures the capital involved in producing a unit of output in 1920 was $2.13 as against $1 in 1900. In the case of railroads the invested capital per ton originating and transported was $.83 as against $1 twenty years earlier. Per revenue ton mile it was $.66 as against $1 in 1900. In agriculture the corresponding figure of invested capital per unit of output was $2.77 as against $1 in 1900, while in mining it was $1.31.

It appears from these figures that the increase in output per unit of capital invested has been greater in railroads than in any other of the principal industries shown above. The results of the analysis of figures for workers, capital invested, and output, when put in common sense language, show that one worker in agriculture, using three and eight-tenths times as much capital, brought forth one and a third times the product of 1900. In manufactures one worker, using two and four-tenths times the capital, brought forth one and one-tenth times the product.

In the case of railroads the capital employed can be easily stated in physical terms. Miles of road owned and miles of track operated are available annually since 1902. The same is true of the number and tractive power of locomotives, and of the cars in service and the carrying capacity of those cars. While all these facilities have increased, there is a disparity in the growth of the various items. The miles of track operated have increased from 259,784 miles to 406,580, or from 100 per cent to 157 per cent. In 1902 the tractive power of all locomotives was 844,494,125 pounds; while in 1920 it was 2,507,075,830. It had increased from 100 per cent to 297 per cent. Tractive power was, therefore, almost exactly three times as large in 1920 as it had been in 1902, when the figures are first available. During this same period the revenue tons carried one mile had increased from 100 per cent to 263 per cent. The revenue tons moved one mile per unit of tractive power in 1920 were, therefore, only 90 per cent of what they had been eighteeen years earlier. The number of revenue tons moved one mile per mile of track was 190 per cent of what it had been in 1902. The other items which go to make up the physical equipment of the railroads with which this service was rendered also increased less rapidly than tractive power. The carrying capacity of freight cars was only 233 per cent of what it had been twenty years earlier. The first track and other main tracks operated were 144 per cent, and the yard tracks and sidings were 210 per cent. Miles of road owned were 131 per cent.

The money capital as shown by the accounts of the railroad had likewise increased less rapidly than the tractive power of the locomotives; and much less rapidly than the money capital of manufacturing establishments. In 1900 the invested capital of the railroads stood at $10,263,313,400, and in 1920 it stood at $19,839,276,119. This was 193 per cent of their capital twenty years earlier.

In mining, each worker using one and three-fourths times the capital brought forth a little more than one and a third units of product. In railroads each worker using slightly less capital than twenty years before transported 18 per cent more tons of freight; and carried each one of these sixty miles, or 25 per cent, farther. Each worker, therefore, carried almost one and one-half times as many tons one mile as twenty years ago.

If we state the same thing from the standpoint of the consumer who must pay, in prices or in rates, wages for the labor and necessary profits on the capital, we find that the capital charge per unit of output in manufactures, and agriculture, has more than doubled; in mining this has increased by one-third; while in transportation it is smaller today than it was two decades ago.

Capital Requirements for Additions and Betterments for Next Ten Years

Details of the $7,870,000,000 capital expenditures by the railroads, estimated recently by the Chamber of Commerce to be necessary in the next ten years, if the railroads are to keep pace with the industrial growth foreseen, have been made public by the Bureau of Railway Economics.

The estimates includes in the way of additions and betterments the following items grouped according to districts:

NUMBER OF UNITS OF EQUIPMENT, TRACKAGE, ETC., REQUIRED IN NEXT TEN YEARS

	Eastern	Southern	Western	Total	All Roads
Additional locomotives.	2,742	893	3,887	7,522	13,200
Additional freight cars	152,880	42,844	217,666	412,990	725,000
Additional pass. cars..	3,131	830	3,045	7,006	12,300
Add. 1st main track, miles	574	677	2,136	3,387	5,950
Add. 2nd or other main track, miles	1,890	787	3,817	6,494	11,400
Add. yard track and sidings, miles......	1,715	332	5,968	8,015	14,050
Total all track, miles..	4,179	1,796	11,921	17,896	31,400
Class yards, number..	34	8	66	108	172
New rail, tons........	.....	16,100	150,000	166,100	291,300
Heavier rail, tons.....	87,990	24,600	255,000	357,590	627,300
Ties, number	12,001,840	920,000	48,242,000	61,163,840	107,304,900

The difference between the figures in the "Total" column and the "All Roads" column is due to the methods used by the Chamber of Commerce in arriving at an estimate. The committee's estimate of $7,870,000,000 was based on the reports of sixty-two roads operating 64.6 per cent of the total mileage and handling 67.6 per cent of the total freight traffic in 1922. By raising the actual figures submitted by these roads to 100 per cent the "All Roads" column is arrived at.

If the above figures pertaining to the various districts were reduced to a dollar and cents per mile of track basis they would show that expenditures per mile are heavier in the Eastern and Southern districts because of the greater density of traffic. The Eastern roads reported 50 per cent of the total expenditures necessary, but their mileage is only 25 per cent of the total mileage, and their freight traffic only 45 per cent of the total.

The Southern roads reported only 9 per cent of the total expenditures necessary, while their mileage is 19 per cent and their freight traffic 30 per cent of the respective totals. The Western roads reported 41 per cent of the total expenditures while their mileage is 56 per cent of the total mileage, and their traffic 35 per cent of the total traffic.

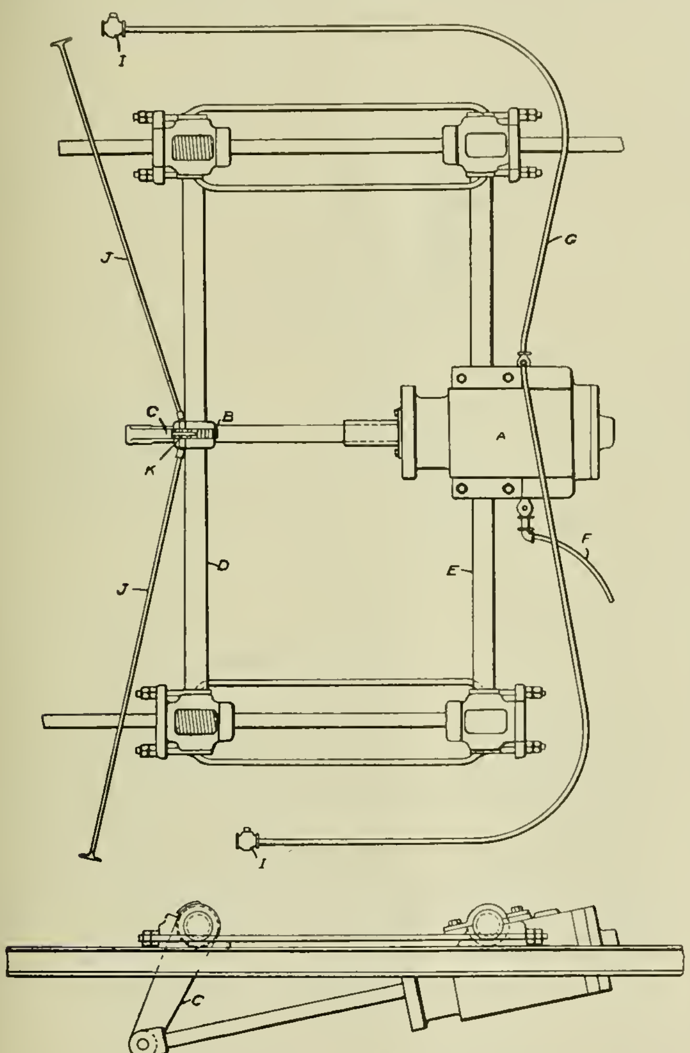
The Chamber of Commerce's estimate was not a program. It was merely a statement of the capital expenditures which the railroads would have to make in order to adequately handle a probable 33 1/3 per cent increase in freight traffic, and 25 per cent increase in passenger traffic by 1934. Whether the railroads will be able to make these expenditures, which average more than $750,000,000 a year, depends upon their earning power and financial credit, in the eyes of the average investor.

Shop Kinks

Some Tools and Devices in Use on the Duluth Shore & Atlantic, the Erie, and the Chesapeake & Ohio That Facilitate Shop Work

Valve Setting Machine

A power operated valve setting machine in use on the Chesapeake & Ohio Ry. was illustrated in the December 1923 issue of this periodical. Here is another in use on the Duluth, South Shore & Atlantic that has been designed and patented by Messrs. Connolly and Herron. Mr. Connolly was formerly superintendent of motive power and Mr. Herron has succeeded him from his former position of master mechanic on the road.



Herron-Connolly Valve Setting Machine

The general construction of the device is the same as that of the old hand-operated machine. There are two shafts, *E* and *D*, to which the rollers are keyed, and which are held in the usual rack. They are carried by bearings in shoes that slide upon the rails and can be drawn together, so as to raise the wheels, by screws and nuts.

The shaft *E* serves as a journal for bearings attached to the steam end of an 8-in. Westinghouse pump cylinder.

The piston rod is lengthened and terminates in a jaw which has a pin connection to the lower end of a lever *C*. The upper end of this lever is journaled on the driving shaft *D*, and carries a pawl *K* working against a ratchet *B*. The pawl can be thrown to drive the ratchet in either direction or to clear on both strokes of the piston so that it will not move, by means of the reversing shafts *I*, that run out to either side of the track.

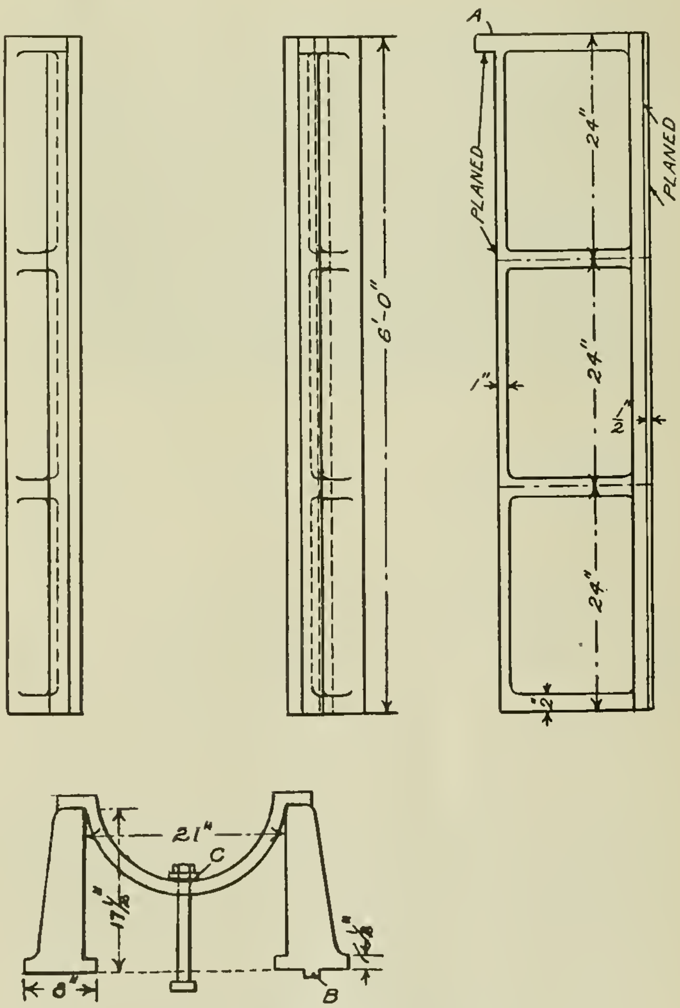
The piston of the cylinder is operated by compressed air, which is led to it through the feed hose *F* and is exhausted through the hose *G*.

The operation is very simple. The air is admitted and the reciprocation of the piston, turns the ratchet through the connections, in the desired direction, until the proper point of the engine stroke has been reached. The pawl can, then, be thrown out or the air shut off, and the machine stopped.

A throwing over of the pawl reverses the motion.

Rack for Planing Eccentric Straps

This rack is a device developed at the Susquehanna shops of the Erie Railroad and is used to hold eccentric straps for planing the two surfaces of the feet that are bolted together.



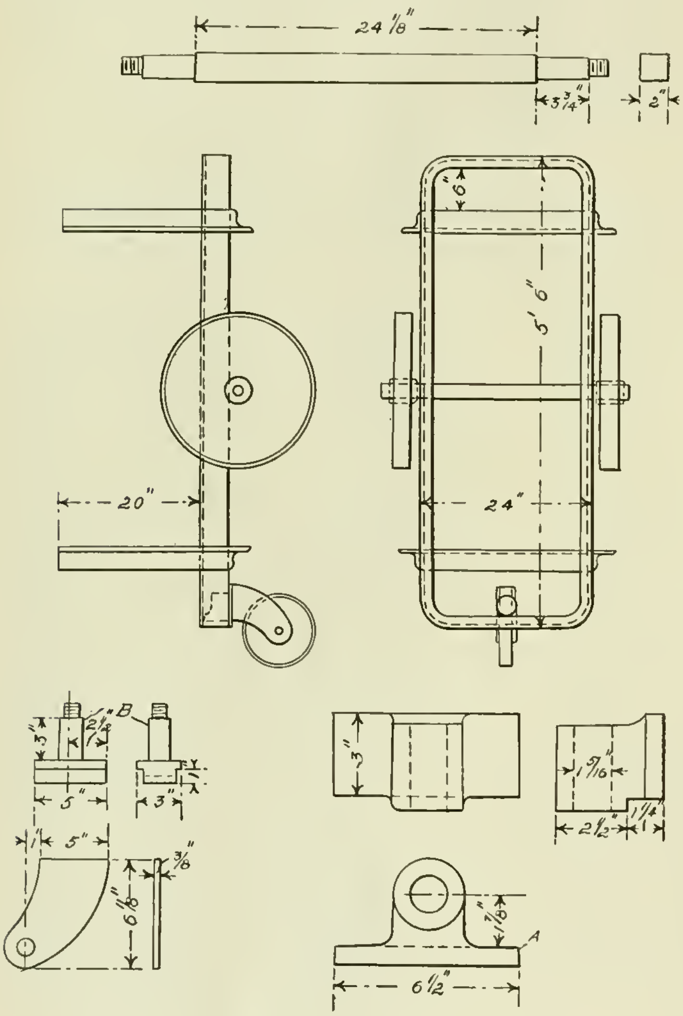
Rack for Planing Eccentric Straps

It is made in two pieces each 6 ft. long. Each piece is of channel section with stiffening ribs at the ends and at two intermediate points. At one end there is an upwardly projecting lug *A*, which serves as an abutment to prevent any movement of the work. One section of the rack *B* has a lug which fits into the slot in the planer bed to hold it in line. This is absent from the other because it must be capable of lateral adjustment in order to meet the requirements of the varying widths of straps.

The racks are bolted to the planer with straps in the usual way, and the eccentric straps are laid on the top surface as shown with the body of the strap dropping down into the space between the rack sections. These are held down and in place by a long strap *C* which is held down by Tee-headed bolts that engage in a slot in the planer platen.

A Flue Truck

Flue trucks are always more or less of a necessity and there are many designs in use. The accompanying illustration shows one of very simple and substantial construc-



Details of Flue Truck

tion. The frame is made of a 4½ in. channel bent and welded into rectangular shape with rounded corners. The racks are of 3 in. by 3 in. angles bent to U-shape and bolted to the underside of the frame, with the legs rising on the outside of the same. The outside dimensions of the frame are 5 ft. 6 in. by 2 ft. and the legs of the rack rise 24 in. above the top of the frame.

The frame is carried by two 22 in. wheels turning on a 2 in. square axle with 1½ in. bearings, which are located midway of its length. At the end there is a single pivoted wheel 10 in. in diameter, which turns in a socket in the casting shown at *A*, the jaw for holding the wheel being made of two side plates ⅜ in. thick welded to the pivot pin *B*.

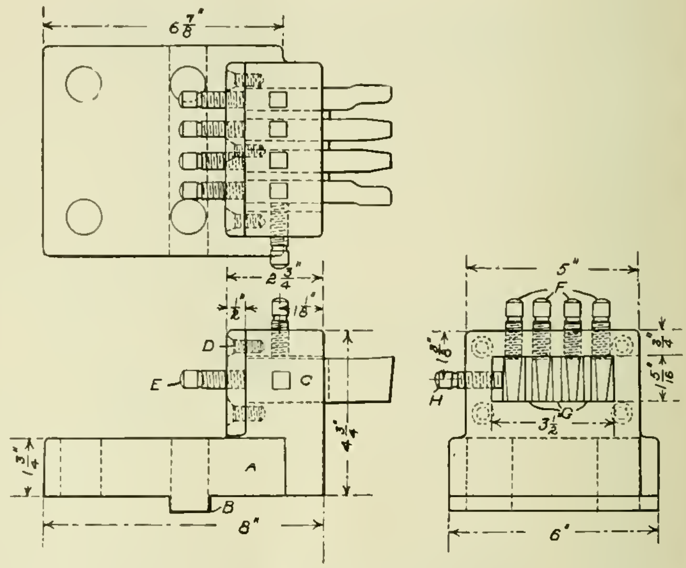
Special Tool Holder for Slotting Back End Main Rod Brasses

The slotting machine is not usually a high-speed tool, and it does have a capacity capable of driving more than a single tool when cutting brass. Hence the use of this gang tool holder for slotting the back end main rod brasses that has been developed in the Richmond shops of the Chesapeake & Ohio Ry.

The holder is made of machinery steel and is L-shaped, the foot *A* being 8 in. high, 6 in. wide and 1¾ in. thick, with a lug *B* made to fit the head of the machine.

The tool-holding portion has an opening 3½ in. long and 1 5/16 in. wide to receive the tools and this is closed at the back by a plate *D* ½ in. thick in which there are four ½ in. set screws *E* spaced ⅞ in. apart for adjusting the tools so that their cutting edges are in alinement.

The tools are ⅝ in. thick and are held by four cor-



Special Tool Holder for Slotting Back End Main Rod Brasses

responding ½ in. set screws *F*. Between the tools there are spacers *G* each ¼ in. thick and these, with the cutting tools are firmly clamped by the single ½ in. set screw *H*.

The method of using the tool is to face down one flange of the box and then feed across the flat for the distance between the tools, and then face down the opposite flange. This completes the work in about one-third the time required to do it with a single cutting tool.

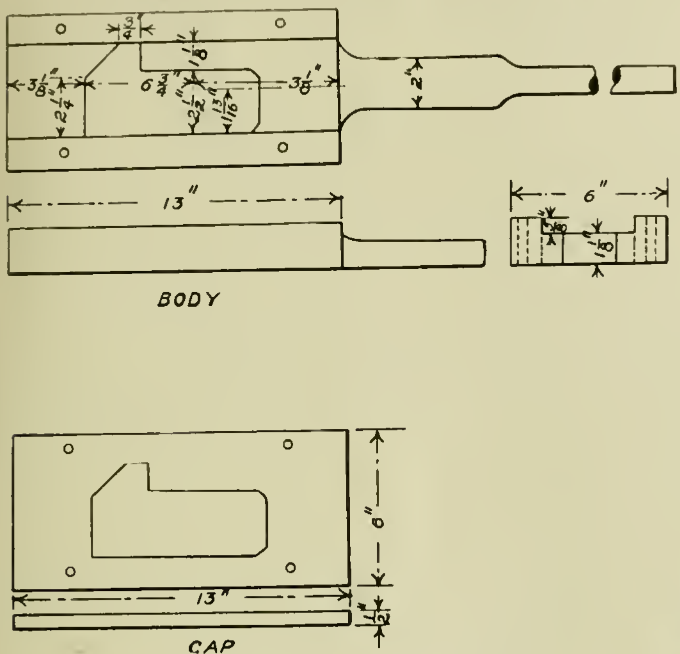
Form and Punch for Drawbar Keys

This is a device for punching drawbar keys from a flat plate. The body or die is made of 1¾ in. by 6 in. steel welded to a 1 in. diameter handle 3 ft. long. It is planed out to a U-shape on cross section and has a hole cut through the bottom in the form of the key, the dimensions of which are given on the engraving. A plate, ½ in. thick is bolted to the upper face and the bar to be cut is slipped into the ⅝ in. by 3⅝ in. space left between the plate and the body of the die. The keys are made from bars of ½ in. by 3½ in. steel which are cut to suitable lengths of from 4 in. to 6 in. These pieces are treated and placed in position as stated above; the punch is dropped into the opening in the plate, the shape of which is shown on the engraving, and it is then driven through with a steam hammer.

The finished key drops into the opening in the body of the die; the waste is removed from the space where the original piece was placed.

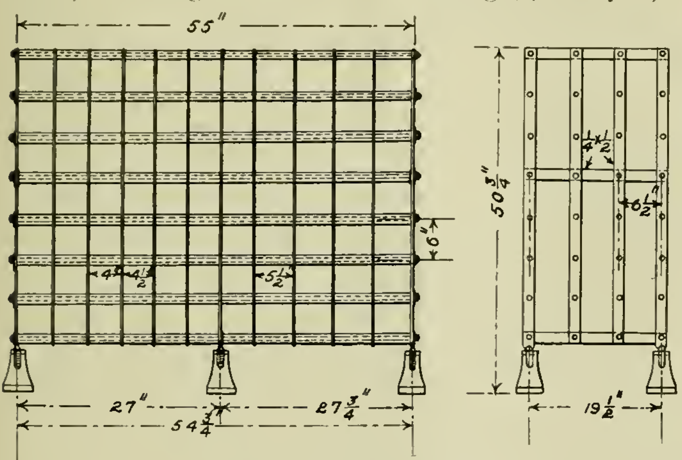
Rack for Wedge Liners

The drawing of this rack is offered as a suggestion for a convenient form of rack for the storage of assorted sizes of any long material. The frame is made of ¼ in. by 1½ in. iron bars drawn out at the lower end to a diam-



Form and Punch for Drawbar Keys

eter of ⅝ in. and then threaded. These uprights are then screwed into cast iron bases. In the case of the rack illustrated they are drilled at 6 in. intervals for ½ in. tie rods which pass through pipe spacers and hold the whole together. In this rack the pipe spacers are made 4½ in. and 5½ in. long. For the latter bracing ¼ in. by 1½



Rack and Wedge Liners

in. flat iron is used. These cross ties or braces are drilled for the distance at which it is desired to have the uprights stand; in this instance it is 6½ in.

The whole rack can be made by the use of a drill press, a hack saw and a set of ½ in. taps and dies. It is a knock down affair and can be taken apart and ressembled with no other tools than a wrench.

1,937 Miles Equipped with Automatic Block Signals Last Year

The mileage equipped with automatic block signals in 1923 was 1,937, as compared with less than 1,200 in 1922, and the mileage equipped with manual block signals was 776 miles, as compared with 292 in the preceding year, according to reports filed with the Interstate Commerce Commission, and compiled by the Bureau of Railway Economics.

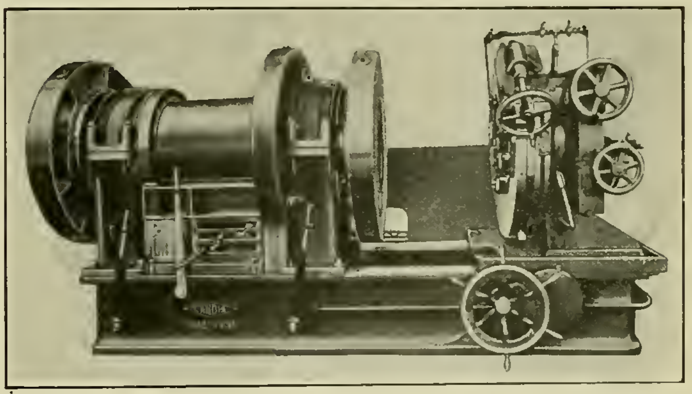
The Landis 20" Pipe Threading and Cutting Machine

The Landis Machine Company, Waynesboro, Pa., have added to their line of pipe threading and cutting machines a 20 in. size. The range of this machine is from 10 in. to 20in., and this entire range is covered by one die head and one set of chasers.

The length of the machine is 12 ft. 2 in., the height is 6 ft. The extreme width of the machine, belt driven, over the belt pulley is 5 ft. 10 in., while the extreme width of the machine, motor driven, over the motor plate is 6 ft. 8 in. It weighs 22,000 pounds.

The machine has a single pulley drive and the variations in speeds, which are eight in number, are obtained by means of a speed box located beneath the main spindle. A friction clutch is mounted on the main drive shaft with the pulley, or if driven by electric motor a chain sprocket will be substituted for the pulley. The operating cone of the clutch is moved by two levers which are located at the ends of the head stock within easy reach of the operator. The forward lever is used for starting and stopping when making up flanges. The lever in the middle is for reversing.

All gears are fully enclosed and with the exception of the main driving gear and its pinion they run in an oil bath. The main bearings of the hollow spindle are lubricated with flat link chains which run in oil contained



Landis Pipe Threading and Cutting Machine

in large reservoirs in the base. The driving pinion shaft as well as the reverse shafts are lubricated by sight feed oilers.

At each end of the hollow spindle there is a three-jawed independent chuck for holding the pipe. The rear chuck is equipped with flange grips for fitting flanges.

The carriage which supports the die head, the cutting off tool, and the reaming tool are moved either by power or by hand. The power traverse or movement is both forward and backward and is controlled by a lever located on the operating side of the carriage. In advancing the carriage toward the chuck, the lever is pulled and held until the threading position for the die is reached. In reversing the movement of the carriage, the lever is pushed forward and held. Releasing the lever stops the carriage at any point within its travel.

Automatic stops prevent the die head from coming in contract with the chuck in the forward movement and the carriage from running off the guides of the machine in the backward movement. The reaming tool is quickly set to position and locked with a lever.

The machine is converted to motor drive by replacing the pulley with a sprocket and mounting the motor on a base over the gear box. A silent chain is employed to drive from the motor to the sprocket.

This machine employs the Landis long life tangential chaser.

Notes on Domestic Railroads

Locomotives

The Atlantic Coast Line Railroad is inquiring for 20 Pacific and 5 switching type locomotives.

The Toledo, Angola & Western Railway has placed an order for one Mikado type locomotive with the American Locomotive Company.

The Detroit & Toledo Shore Line is inquiring for 3 Mikado locomotives.

The Yosemite Valley Railroad has ordered one Mogul type locomotive from the American Locomotive Company.

The New York Central Railroad is reported to be preparing figures covering the purchase of 100 locomotives.

The Norfolk & Western Railway is inquiring for 10 locomotive-tenders.

The Baldwin Locomotive Works has placed an order for 57 steel underframes, for use on the Atchison, Topeka & Santa Fe Railway, locomotives with the Penn Seaboard Steel Co.

The Valley & Siletz Railroad has ordered one locomotive from the H. K. Porter Co.

The Maine Central Railroad is inquiring for 2 Pacific type and 6 Mikado type locomotives.

The Kansas City Southern Railway is inquiring for one locomotive tender.

The Madras & Southern Mahratta of India has ordered 2 Mikado type and 2 Pacific type locomotives from the Baldwin Locomotive Works.

The New York, New Haven & Hartford Railroad is inquiring for 2 locomotive tenders.

The Atchison, Topeka & Santa Fe Railway has purchased 57 locomotives from the Baldwin Locomotive Works as follows:—10 Pacific, 6 Mountain type, 26 Mikados and 15 Santa Fes.

The Pennsylvania Railroad has authorized the construction of 50 locomotives at its own shops at Altoona, Pa.

The Western Pacific Railroad has placed an order for 5, 218-ton Mallet type locomotives with the American Locomotive Company.

The Lackawanna Railroad is reported to have appropriated $1,600,000 for the purchase of 25 new locomotives.

The Georgia, Florida & Alabama Railway has placed an order for 2 Decapod type locomotives with the Baldwin Locomotive Works.

The Argentine State Railways are reported to have purchased 5 Mikado type locomotives from the Baldwin Locomotive Works.

The Texas-Mexican Railway has ordered one 10-wheel locomotive from the Baldwin Locomotive Works.

The South Manchuria Railway has placed an order for 5 Mikado type locomotives with the American Locomotive Company.

The Canadian National Railways are inquiring for 5, 2-10-2 type locomotives.

The San Joaquin & Eastern Railroad is reported to have purchased one Prairie type locomotive from the Baldwin Locomotive Works.

The Webb Logging & Timber Company has placed an order for one 90-ton Shay locomotive with the Lima Locomotive Works.

The Cherokee Company has ordered one Shay locomotive from the Lima Locomotive Works.

The Mobile & Ohio Railroad has placed an order for 3 Mikado type locomotives with the Lima Locomotive Works, and 2 Pacific type locomotives with the Baldwin Locomotive Works.

Freight Cars

The Pacific Coast Railroad has placed an order for 15 general service cars and 5 dump cars with the Pacific Car & Foundry Co.

The Western Pacific Railroad has placed an order for 775 refrigerator cars with the American Car & Foundry Company.

The Union Pacific Railroad is reported to be in the market for 500 tank cars.

The Philadelphia & Reading Railway has ordered 50, 40-ton steel underframe stock cars from the Standard Steel Car Company.

The Maine Central Railroad is inquiring for 100, 50-ton general service cars and 250, 40-ton box cars.

The Northern Pacific Railway has ordered 1,000 steel underframes from the Western Car & Foundry Company.

The Fruit Growers' Express has placed an order for 1,000 steel underframes with the Pressed Steel Car Company.

The Northern Pacific Railway has placed an order for 1,000 steel underframes with the Pressed Steel Car Company.

The Swift Car Lines are reported to be in the market for 300 refrigerator car underframes.

The Pensylvania Railroad is in the market for 3,000 box car bodies, and 300 steel underframe box car bodies.

The Chesapeake & Ohio Railway has placed an order for 5 steel underframes for caboose cars with the Illinois Car Manufacturing Co.

The Western Pacific Railway is in the market for 200, 70-ton ore cars.

The Philadelphia & Reading Railway will build 20 caboose cars in their own shops.

The Louisville, Henderson & St. Louis Railroad has ordered 20 ballast cars from the American Car & Foundry Company.

The Philadelphia & Reading Railway has ordered 600 steel hopper coal cars of 70 tons' capacity from the Pressed Steel Car Company, 200 from the Standard Steel Car Company, 200 from the Cambria Steel Company and 200 from the American Car & Foundry Co.

The Central of Brazil is inquiring for 100 freight cars.

The Nashville, Chattanooga & St. Louis Railway is inquiring for 50, 55-ton all steel hopper ballast cars.

The New York, Ontario & Western Railway contemplates building about 15 caboose cars at its Middletown shops.

The Central Steel Company is inquiring for 12 low side gondola cars.

The Bangor & Aroostook Railroad has ordered 75 steel underframes from the Pressed Steel Car Company.

The Chile Exploration Company has placed an order for 80 ore cars of 80-tons' capacity with the Pressed Steel Car Company.

The American Car & Foundry Company is reported to have received an order for 1,200 freight cars from the West Australia Railways.

The Commonwealth Steel Company is inquiring for 50, 85-ton steel ore cars.

The Atchison, Topeka & Santa Fe Railway is in the market for 5,200 freight cars as follows: 2,000, 40-ton refrigerator cars; 1,000, 40-ton box cars; 500, 50-ton gondolas; 500, 40-ton flat cars; 500, 40-ton automobile cars; 500, 40-ton stock cars and 200 dump cars.

The Northern Pacific Railroad is inquiring for 200, 75-ton ore cars.

The Illinois Traction Company is reported to have placed an order for 100 box cars with the American Car & Foundry Company.

Passenger Cars

The Lehigh & Hudson River Railway has placed an order for 10, 40-ton milk cars with the American Car & Foundry Company.

The Maine Central Railroad is inquiring for 4 baggage and mail cars, 6 coaches, and 3 smoking cars.

The Chesapeake & Ohio Railway has placed an order for 6 mail cars with the Pullman Company.

The Baltimore & Ohio Railroad is reported to have placed 55 coaches with the Pullman Company.

The Chicago, Burlington & Quincy Railroad has ordered 6 dining cars from the Pullman Company.

The New York, New Haven & Hartford Railroad contemplates letting a contract soon for the construction of 10 gasoline passenger motor cars.

The Great Northern Railway has placed an order for 8 dining cars from the Pullman Company.

The Chicago, Great Western Railroad has placed an order with Sykes Company for 2 gasoline motor cars and trailers.

The Missouri Pacific Railroad has purchased 3 combination passenger and baggage cars from the J. G. Brill Company.

The International & Great Northern Railway has placed an order for three gasoline passenger cars and one gasoline baggage-mail car with J. G. Brill Company.

The Missouri Pacific is in the market for three gasoline motor cars for passenger service.

The Pond Fork & Bald Knob Railroad has placed an order for one gasoline car with the J. G. Brill Company.

The Virginia & Carolina Southern Railroad has placed an order for one gasoline motor car for passenger service with the Edwards Railway Motor Car Company.

The Gulf Texas & Western Railroad has placed an order for one gasoline car with the J. G. Brill Company.

The New York Central Railroad is inquiring for 50 coaches, 20 dining cars, 25 baggage cars, 20 passenger baggage cars and six baggage-mail cars.

The Lehigh Valley Railroad has purchased 25 steel underframe milk cars from the American Car & Foundry Company.

The Central of Georgia Railway has placed orders for six coaches, four mail-baggage cars, three baggage-express cars, and two combination coach and baggage cars with the Pullman Company.

The Alabama & Vicksburg Railway has placed an order with the American Car & Foundry Company for five passenger cars, two combination baggage cars, and one straight baggage car.

The Canadian Pacific Railway has ordered 10 steel frames for coaches from the National Steel Car Corporation.

Building and Structures

The Central of Georgia Railway plans the reconstruction of its car shops at Savannah, Ga., which were destroyed by fire.

The Louisville & Nashville Railway has purchased land near Whitesburg, Ky., on which it is planned to erect a roundhouse, shops, etc.

The Wabash Railway has purchased 31 city lots adjacent to its present shops at Ft. Wayne, Ind. The property to be used for expansion of its shops at this point.

The Southern Pacific Company plans the construction of a locomotive erecting shop with 24 engine pits at Los Angeles, Cal., at an estimated cost of $300,000.

The Wabash Railway plans the construction of a car and locomotive repair shop at Peru, Ind.

The Pennsylvania Railroad plans two additional shops at Juniata, Pa.

The Norfolk & Western Railway has awarded contract to the Robert & Shaefer Co. for the erection of a large coaling plant at Pirchard, West. Va., to hold 2,000 tons of coal and to coal locomotives on six tracks.

The Atchison, Topeka & Santa Fe Railway has completed plans for enlargement to its shop at Emporia, Kans. These improvements will consist of a powerhouse, machine shops and other structures.

The Oklahoma Union Railway plans the construction of car repair shops and powerhouse in connection with the extension of its line to Bristow, Okla., also a powerhouse at West Tulsa, Okla.

The Southern Railway is planning a one-story addition to its shops at Somerset, Ky., to cost approximately $100,000 including equipment.

The Baltimore & Ohio Railroad is planning a two-story addition to its shops at Mount Clare, Md., to cost approximately $27,000.

The New York, Chicago & St. Louis Railroad will construct a one-story machine shop at Conneaut, Ohio, at an estimated cost of $40,000.

The Illinois Central Railroad is reported to be planning the construction of shops, roundhouses and a coaling station at Sioux City, Iowa.

The New York Central Railroad has plans for rebuilding the portion of its repair shops, forge and woodworking shops at Clearfield, Pa., recently destroyed by fire.

The New York, New Haven & Hartford Railroad is reported to be planning the construction of a repair shed, sheet metal, at Stamford, Conn., to cost approximately $60,000.

The Joplin Union Depot Company will rebuild its roundhouse recently destroyed by fire at Joplin, Mo.

The Texas & New Orleans Railroad has awarded a contract to the Southwestern Construction Company for the concrete work for its shops at Houston, Texas.

The Texas & Pacific Railroad has prepared plans for a new engine shop, engine house, car works and other buildings at Belt Junction, to cost approximately $750,000.

The Erie Railroad plans the construction of locomotive and car shops and a power house at Hammond, Ind., to cost approximately $500,000.

The Southern Railway plans the construction of a one-story addition to its locomotive and repair shop, at Ferguson, Ky.

Items of Personal Interest

A. B. Edwards of the Seaboard Air Line Railway has been appointed assistant road foreman of engines with headquarters at Hamlet, No. Car., succeeding **B. Koontz**, who has been transferred.

H. S. Wall, mechanical superintendent of the Atchison, Topeka & Santa Fe Railway with headquarters at Los Angeles, Calif., has been granted a leave of absence, and **John Pullar**, master mechanic has been appointed acting mechanical superintendent.

R. D. Smith, superintendent of motive power and rolling stock of the Boston & Albany Railroad with headquarters at Boston, Mass., retired from active service at his own request. **F. A. Butler**, division master mechanic with headquarters at West Springfield, Mass., has been appointed superintendent of motive power and rolling stock with headquarters at Boston, succeeding Mr. Smith.

G. B. Pauley, general foreman on the Chicago, Burlington & Quincy Railroad with headquarters at Kansas City, Mo., has been promoted to acting assistant master mechanic of the Galesburg division with headquarters at Galesburg, Ill., succeeding **D. Nott**, granted leave of absence.

Daniel Hubbard, of the Chesapeake and Ohio Railway, was appointed division engineer of the Chicago division with headquarters at Peru, Ind.

J. J. Hamlin, superintendent of motive power of the Southern District of the Seaboard Air Line, has his headquarters transferred from Savannah, Ga., to Jacksonville, Fla.

P. T. Robinson, of the Southern Pacific Company was recently promoted to the position of division engineer on the Tucson division with headquarters at Tucson, Ariz.

B. N. Lewis, of the Minneapolis, St. Paul & Saulte Ste. Marie Railway, has been appointed mechanical superintendent with headquarters at Fond du Lac, Wis. **L. Ernest** has been appointed general master mechanic with headquarters at Shoreham Shops, Minneapolis, Minn. **J. W. Hendry** has been appointed master mechanic of the Winnipeg division with headquarters at Thief River Falls, Minn. **F. M. Roberts** has been appointed master mechanic, Missouri River division, with headquarters at Bismarck, N. D., and **H. Halvorson** has been appointed assistant superintendent of car department Chicago division with headquarters at Fond du Lac, Wis.

J. J. Corcoran, superintendent of the Detroit Canadian division of the Pere Marquette Railway resigns. Mr. Corcoran's resignation became effective January 1st, following his acceptance of the managership of the Greenville Gravel Company, Germantown, Ohio. He is succeeded by **D. J. Swope**, superintendent of the Toledo Ludington division, with headquarters at Saginaw, Mich. **W. H. Wallace**, superintendent of the Grand Rapids Port Huron division with headquarters at Saginaw, Mich., became superintendent of the Toledo Ludington division succeeding Mr. Swope. **J. A. Gregware**, assistant superintendent of the Detroit Canadian division, is promoted to the superintendency of the Grand Rapids Port Huron division succeeding Mr. Wallace.

Millard F. Cox, of the Louisville & Nashville Railroad has been appointed superintendent of machinery with headquarters at Louisville, Ky. **J. A. Rabuck** has been appointed mechanical engineer with headquarters at same place.

C. J. Scudder, of the Delaware, Lackawanna & Western Railroad, has been appointed superintendent of motive power and equipment with headquarters at Scranton, Pa.

Samuel Russell, of the Boston & Albany Railroad, has been appointed division master mechanic with headquarters at West Springfield, Mass., succeeding Mr. Butler.

R. G. Henley, master mechanic of the Norfolk & Western Railway, has been promoted to assistant to the superintendent of motive power with headquarters at Roanoke, Va. **O. F. Hark**, master mechanic, has been transferred from Bluefield, W. Va., to Portsmouth, Ohio, succeeding Mr. Henley. **J. L. Barry**, general foreman, with headquarters at Columbus, Ohio, has been promoted to master mechanic, succeeding Mr. Hark.

J. J. Simmons, of the Chicago, Burlington & Quincy Railroad, has been appointed assistant master mechanic of the Hannibal division, with headquarters at Hannibal, Mo.

Supply Trade Notes

The **Pyle National Company** announces the following appointments: **Crawford McGinnis** has been appointed vice-president; **L. H. Vilas** has been appointed assistant general manager, and **George E. Haas** has been appointed special representative.

Joseph T. Ryerson & Son Co., has awarded contract to **W. E. Wood Company** for a one-story factory addition to cost approximately $81,000 at its Detroit plant.

Fred M. Ball has been appointed district manager of the **Franklin Railway Supply Company, Inc.**, with headquarters at Philadelphia, Pa. Mr. Ball has service as resident inspector at the **Baldwin Locomotive Works** for the Franklin Railway Supply Company, Inc.

Victor R. Willoughby, acting general mechanical engineer of the **American Car & Foundry Company**, has been appointed general mechanical engineer in charge of the engineering section, and **J. A. V. Scheckenbach** has been appointed general improvement engineer in charge of the improvement and research section, both with headquarters at New York City.

Horace W. White, Jr., of the **T. H. Symington Company**, has been appointed southern sales manager with headquarters at Baltimore, Md., to fill the position formerly held by **T. C. DeRosset**, deceased.

W. J. Behlke, formerly mechanical representative of Barco Manufacturing Company, Chicago, has been appointed district sales manager.

Joseph B. Deisher has been appointed assistant superintendent of the American Malleable Castings Association. Mr. Deisher was formerly connected with the T. H. Symington Co., Rochester, New York.

The Q. & C. Company of New York City announces the following changes in its personnel: Frank F. Kister has been elected president and Charles F. Quincy has been elected chairman. Edgar M. Smith, Richard J. McComb, James L. Terry and Lester T. Burwell have been elected vice-presidents and E. Ray Packer has been elected vice-president in charge of manufacturing. Marinus Iseldyke, Jr., has been appointed secretary and assistant treasurer, Ralph R. Martin has been appointed auditor and Chester A. Gaskill has been appointed assistant secretary and cashier.

The Westinghouse Electric & Manufacturing Co. plans additions to its transformer plant at Sharon, Pa., which will double the output of that plant.

F. O. Brazier, manager eastern railway sales of the Murphy Varnish Company, has been made general manager of railway sales with headquarters at Newark, N. J.

The Springfield Railway Equipment Co., Springfield, Mo., has been incorporated for the purpose of manufacturing and selling railway cars and supplies.

Alexander McIver has been appointed supervisor of heavy traction development for the Westinghouse Electric & Manufacturing Co. Mr. McIver has been with Westinghouse since 1900. Previous to that time he was connected with the Sprague Electric Co.

The Electric Storage Battery Co., Philadelphia, is building a new factory branch in St. Louis, Mo. The location is at Vandeventer and Chouteau avenues, and it will afford 32,000 square feet of floor space.

LeGrand Parish, who has been president of Lima Locomotive Works, Inc., since 1918 has resigned to devote his entire attention to the American Arch Company, Inc., of which he is also president. He will, however, remain on the executive committee of the former company. J. S. Coffin has been elected president of the Lima Locomotive Works, Inc., to succeed Mr. Parish.

Col. Edward M. Hadley, vice-president and treasurer of the Chicago, Cleveland Car Roofing Company, has been appointed chairman of the Railway Supply division of Ways and Means Committee of the Chicago Association of Commerce for 1924.

The Southern Wheel Co. is constructing a branch plant at Portsmouth, Va., for the manufacture of car wheels. The new plant is to be 90 ft. by 340 ft.

The Union Tank Car Co., New York City, N. Y., has plans in preparation for a one-story steel car repair shop and plate works at Point Breeze, Philadelphia, estimated to cost $300,000 with equipment.

The Wason Manufacturing Co., Springfield, Mass., a subsidiary of the J. G. Brill Co., Philadelphia, announces the following appointments effective January 1st, 1924: A. H. Pease, formerly secretary, has been elected vice-president, succeeding Henry Pearson, who died recently. Charles F. Johnson, general manager; Walter Abrahams, secretary and clerk; R. T. Foster, superintendent.

The Central Railway Signal Company has been incorporated for $200,000 by M. L. Cox, of Somerville, Mass., to manufacture railway appliances.

L. P. Duggan, formerly of the Garlock Packing Company, and recently of the United States Rubber Company, has resumed his affiliation with the Garlock Packing Company organization. His headquarters will be at Garlock sales branch, 1211 Arch St., Philadelphia, Pa.

Obituary

William A. Winburn, president of the Central of Georgia Railway, died at Rochester, Minn., on January 8, at the age of sixty. He served as president from April 8, 1914 until his death, except from June, 1918, to March, 1920, during the period of federal control, when he served as federal manager.

Arthur Melville White, for many years superintendent of the American Locomotive Company, at Schenectady, New York, died at Manchester, N. H., on January 12, at the age of seventy-eight.

Charles C. Young, owner of Charles C. Young Manufacturing Co., Jersey Shore, Pa., successor to American Balance Valve Co., died recently.

Edwin A. Hall, assistant secretary and treasurer and assistant to the president of the Standard Stoker Company, Inc., died on January 20, at Scarsdale, New York. Mr. Hall's headquarters were at the New York office, Grand Central Terminal.

Locomotives Built for Foreign Countries

Chile was the heaviest buyer of steam locomotives from the United States during the year 1923, having purchased a total of 26. The complete list of exports for the year follows:

Argentine	2
Brazil	13
Chile	26
China	1
Cuba	19
Cyprus	1
Jamaica	1
Japan	1
Manchuria	6
Mexico	2
Peru	1
Porto Rico	4
Portuguese East Africa	2
Santo Domingo	2
Venezuela	2

Railway and Locomotive Engineering

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Southern Pacific Heavy 4-8-2 Type Locomotive

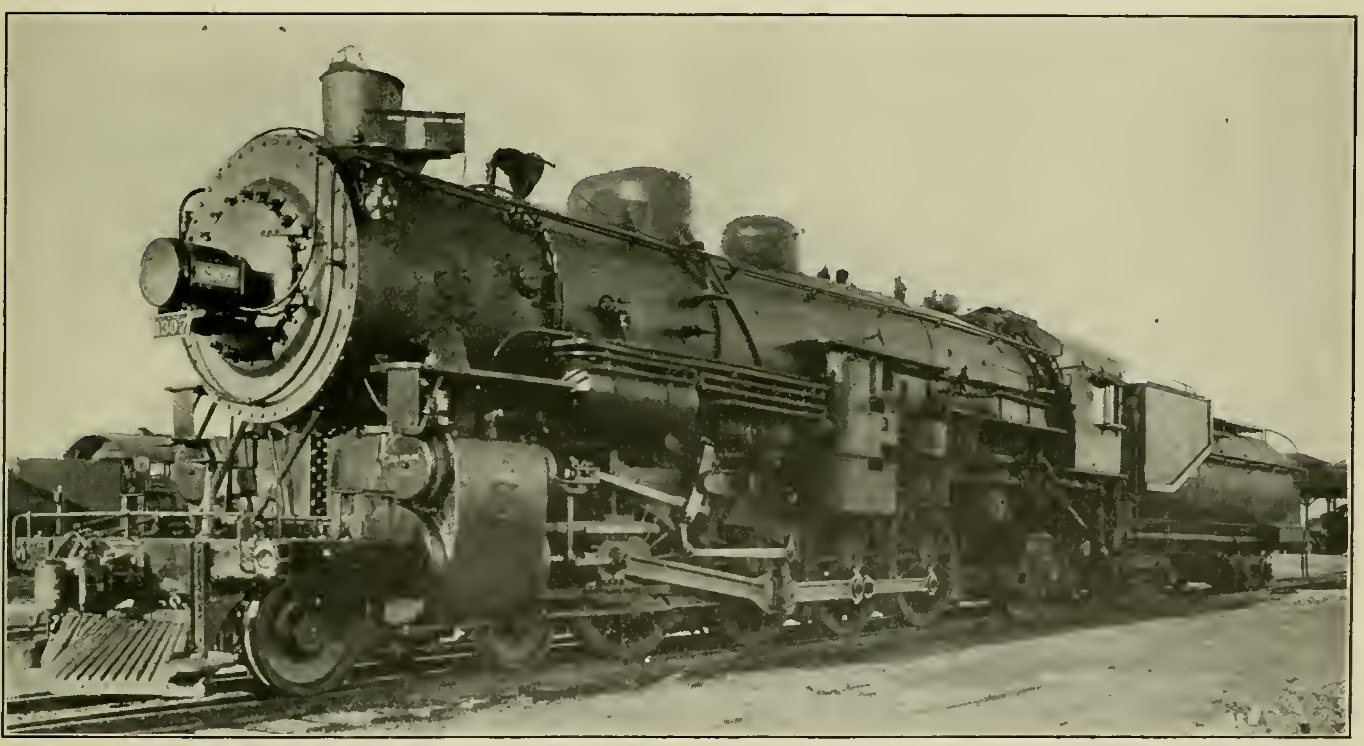
Designed for Heavy Long Run Passenger Service Over Two Per Cent Grades

In 1921 the Southern Pacific placed in service a number of powerful 4-6-2 type locomotives which hauled 11 heavy passenger cars on a 1.5 per cent grade and established a record for long locomotive runs. These locomotives have been regularly hauling passenger trains between Ogden, Utah, and Sparks, Nev., a distance of 536 miles, and have averaged better than 10,000 miles per month, fully meeting the expectations of the Southern Pacific in adopting a longer stroke for superheated passenger locomotives, thus keeping down cylinder clearances and obtaining a more economical steam consumption.

The Southern Pacific has been the leader among the railroads of the country in developing the growing practice of extending locomotive runs, and has just made another advance by placing in service ten 4-8-2 type locomotives to haul their heavy passenger trains between Los Angeles, Cal., and El Paso, Tex. These locomotives were especially designed for this long run over that difficult mountain and desert territory, a distance of 815 miles, which is made without changing locomotives, thus establishing a new record for long locomotive runs. It is anticipated that these locomotives will average about 12,000 miles per month.

The general design and specifications for these locomotives were worked up under the supervision of Mr. George McCormick, general superintendent motive power, and Frank E. Russell, assistant mechanical engineer; the design being completed and details worked out with the American Locomotive Co., who built the locomotives. The outstanding characteristics sought in this design were maximum tractive power within the weight limits, and ample boiler capacity for the long-sustained runs. This required refinement in design throughout to provide ample strength with minimum weight in all parts, which necessitated the use of special materials of high tensile strength for many parts.

The character of the territory over which these locomotives are operating is shown on the accompanying profile.



Heavy 4-8-2 Type Locomotive of the Southern Pacific—Built by American Locomotive Company

Grades of 2 per cent occur from Colton to Beaumont going east, and from Indio to Beaumont going west. Also from Tucson to Dragoon going east, there are grades of 1.5 per cent. Previously the through passenger trains were hauled over the districts which have the heaviest grades by 2-8-2 type locomotives, and by 4-6-0 type locomotives and 4-6-2 type locomotives where grades are lighter. With trains varying from 8 to 12 cars, the time card calls for schedules for Sunset Limited trains of 24.2 miles per hour from Colton to Beaumont, and of 26.2 miles per hour from Indio to Beaumont. From Tucson to Dragoon the schedule is about 30 miles per hour. Most of the remaining portions of the line consist of grades of approximately 1 per cent, the schedule varying from 38 to 42 miles per hour. It is expected that the new 4-8-2 type locomotives, which have a high sustained steaming capacity, will bring the maximum and minimum operating speeds nearer to the average, which will materially reduce the maintenance costs of locomotives and track.

These 4-8-2 type locomtives have a total weight of 368,000 lbs., of which 246,000 lbs. are on the drivers. The maximum tractive effort is 67,660 lbs. with booster, and 57,510 lbs. without the booster, the ratio of adhesion for drivers being 4.28. Using Cole's ratios as a basis of comparison, they have a maximum horse power capacity of 2,965 and a boiler capacity of 103.4 per cent including the increase obtained by the use of the feed water heater. This high percentage of boiler capacity indicates that the boiler can supply the cylinders at high speeds without forcing.

The boiler was designed with the largest proportions possible to obtain ample steaming capacity, and at the same time, to keep within safe limits of wheel load on track. It is conical in form, with an outside diameter of 84 inches at the front barrel course, increasing to 95 inches at the combustion chamber course. The firebox measured 121 1/16 in. by 90 in. inside of sheets at the mud ring, and includes a combustion chamber 75 in. in length, which provides for tubes 21 ft., 6 in. long. The steam space above crown sheet is 30 inches at back end, and 25¼ inches at front end. The Schmidt type superheater is installed, which consists of 45 units, with a superheating surface of 1,162 square feet.

The boiler shell is of 25/42-in. material for the first course and ⅞-in. for the second and third courses; and the wrapper sheet is ½ in. thick. The firebox and combustion chamber sheets are ⅜ in., excepting the inside throat connection which is 9/16 in. thick, and is welded.

The frames, as well as all other castings subjected to heavy stresses, are made of high grade cast steel, thus permitting considerable reduction in weight. They are unusually well braced throughout. The driver brake cylinders are secured to the main frames just back of the steam cylinders and placed in a horizontal position, thus relieving the frames of unnecessary stresses due to braking. The rear section is a Commonwealth Steel Company's cradle casting, the front end of which is so designed that the trailing truck can be dropped down without moving the track back. This facilitates making repairs to the booster.

One of the outstanding features in the design of this locomotive is what has been accomplished in obtaining increased tractive effort without increasing the stresses set up in the track and roadbed. To accomplish this, the engine is equipped with a constant-resistance centering device. Also, the forward pair of drivers is fitted with the Franklin lateral motion device, thus making ample provision for the engine to take curves with a minimum stress in the track. These centering devices also hold the engine steady on a tangent track, reducing to a minimum the lateral movement due to the steam action.

In order to keep down the dynamic augment to a minimum, the engine is equipped with connecting rods of normalized carbon Vanadium steel ot I-section, hollow piston rods and Z-type pistons, thus providing light reciprocating parts, 50 per cent of which are balanced. The total weight of the reciprocating parts is 1,830 lbs., or one pound to each 201 lb. of the total weight of the locomotive in working order as compared with the ratio of 1 to 160, which is considered good practice.

Special materials were used in parts subjected to heavy stresses as follows:

QUENCHED AND TEMPERED STEEL

TENSILE STRENGTH 85,000 LBS. PER SQ. INCH

Crank pins.
Main crank pins, hollow bored.
Piston rods, hollow bored.
Driving axles, hollow bored.
Engine truck axles.
Trailing truck axles.

NORMALIZED CARBON-VANADIUM STEEL

TENSILE STRENGTH 90,000 LBS. PER SQ. INCH

Main and side rods.

SPECIAL GRADE CAST STEEL

TENSILE STRENGTH 75,000 LBS. PER SQ. INCH

Main frames.
Frame cross ties.
Frame filling castings.
Driving and trailing wheel centers.
Driving and trailing boxes.
Pedestal caps.
Pistons.
Cylinder heads.
Back steam chest heads.
Cross heads.
Lateral motion driving box, spacer and rocker.
Engine truck swing frame and rocker.
Driving spring stirrups.
Guide yokes.
Spring saddles.
Link supports and cheeks.
Reverse shaft bearings.
Bumper brackets.
Engine truck center plate.

The cylinders follow the American Locomotive Company's light design, except that the exhaust passages have been enlarged considerably above those which are in general use. The size of the opening at the top of the saddle is 12 in. by 7 in., providing unrestricted exhaust passages up to the exhaust nozzle. The exhaust stand is secured by twelve 1⅛ in. tee-head bolts. The exhaust passages of the cylinders are extended 4 in. above the cylinder saddle and provided with a 1⅛ in. flange, well reinforced with ribs, extending down to and adjoining the cylinder saddle. This construction eliminates troubles experienced in maintaining a tight joint, the absence of which interferes with the draft of the locomotive. The cylinders provide for outside steam pipes and connections for superheated steam to the booster and exhaust steam to the feedwater heater. The depth of the casting over the frame section gives a very strong construction with minimum weight.

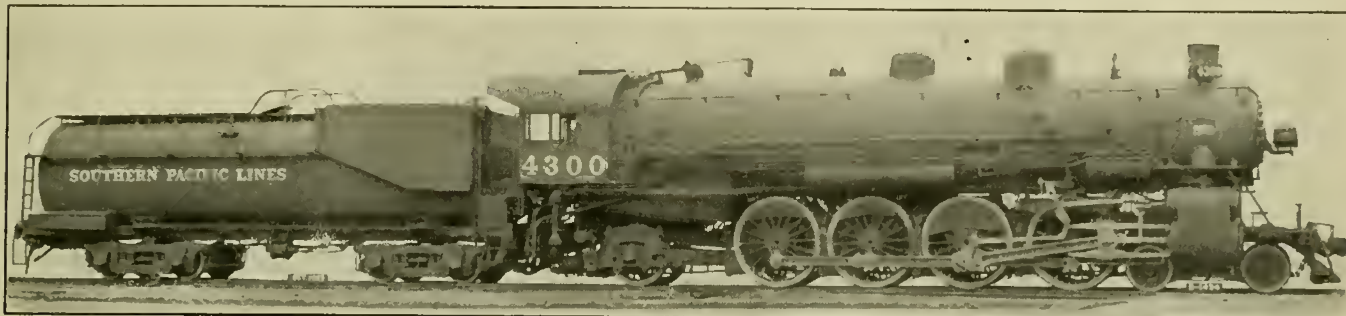
The smokestack is a new design of the railroad company. It consists of four iron castings, assembled in such a manner that the extension of the stack in the smokebox can be easily and quickly removed. The castings forming the extension, which are most subject to wear, can be replaced by new castings with very little trouble and without disturbing the alignment of smokestack and base. The casting forming the lower portion of the extension is so designed that the height of the bell above the exhaust nozzle may be increased or decreased to give the best draft conditions. This feature also makes the stack applicable to a number of other types of locomotives.

The journal bearings throughout are unusually large, especially the main, which is 13 in. in diameter by 22 in. long. The frame brace cross ties forming the extended pedestals for the main driving boxes are of high grade cast steel and in addition to being well secured to frame pedestals are tied together top and bottom by supplementary pedestal binders which add much to the rigidity of the pedestals and prevent journal bearings and axles from wearing conical.

The Franklin Railway Supply Co.'s locomotive booster type C-1, is applied, the steam supply for which is taken from the steam chest of the main cylinders instead of located just below the cab floor, which is the practice on many roads for large power. A further saving of 300 lb. is thus effected. Moreover, for convenience of the enginemen, the blow-off cocks are operated by means of two levers located in the cab, one on each side.

The feedwater is supplied by one Worthington combined feedwater heater and a pump of 7,200 gal. capacity per hour, placed on the left side, and by one Nathan non-lifting injector, placed on the right side, the latter being used only in cases of emergency and when the locomotive is not working.

The tender is of the Vanderbilt type, carrying 4,000 gal. of oil and 12,000 gal. of water. The tank is carried on a Commonwealth cast steel frame, made in one piece with the bumpers and the transverse bolsters, which serve as tank supports. The trucks are of the Commonwealth



Right Side View Southern Pacific Locomotive of 4-8-2 Type

from the steam dome. Superheated steam is thereby used in place of saturated steam, reducing steam consumption for the operating of the booster engine.

It is interesting to note that the spring rigging has been constructed to incorporate bent equalizers similar to those used on the Southern Pacific 2-8-2 type locomotives which were placed in service some twenty years ago. This design of equalizer provides a more stable construction by keeping the spring rigging in alignment, particularly on 4-8-2 type locomotives. On lighter power this type of equalizer is not so essential, and the advantage of its use has for some time been practically overlooked. The Southern Pacific has again brought this design into use by installing the bent equalizers on their 4-8-2 type locomotives, which will obviate the trouble ordinarily experienced with the spring riggінig on this type of locomotive.

The Westinghouse No. 6 ET brake equipment is applied, the air being supplied by one 8½-inch cross compound compressor. The application of brakes to the trailing truck wheels brings the braking power of these locomotives up to the maximum, since this results in all the wheels of the locomotive being equipped with brakes. Clasp brakes are used on the tender truck wheels.

Another source of reduction in weight without sacrificing strength is in the application of a shorter and somewhat narrower cab. By placing the steam turret on the outside of the cab at front, it was possible to make a material reduction in the length of the cab. By eliminating the two doors at the front, which with large size boilers have, of necessity, always been made so narrow as to be very impractical, the width of the cab has also been decreased. However, a window at the front on each side has been applied. The saving in weight on account of the application of the smaller cab amounts to about 200 lb. To take the place of cab doors, the steel floor of the cab to be used as a running board and hand-holds have been conveniently located near the eaves to enable enginemen to pass around outside of the cab to and from the running board at front. This extra width of cab floor dispenses with the use of supplementalry running boards.

design, with cast steel frames and swing bolsters. This is an equalized pedestal type of truck.

The principal dimensions, weights and proportions of these locomotives are given in the accompanying table:

TABLE OF DIMENSIONS, WEIGHTS AND PROPORTIONS

Type of locomotive	4-8-2
Service	Passenger
Cylinders, diameter and stroke	28 in. by 30 in.
Valve gear, type	Walschaert
Valves, piston type, size	14 in.
Weights in working order:	
On drivers	246,000 lb.
On front truck	61,500 lb.
On trailing truck	60,500 lb.
Total engine	368,000 lb.
Tender	226,900 lb.
Wheel base:	
Driving	20 ft. 0 in.
Rigid	13 ft. 0 in.
Total engine	42 ft. 3 in.
Total engine and tender	83 ft. 6 in.
Driving wheels, diameter outside tires	73 in.
Boiler:	
Type	Conical
Steam pressure	210 lb.
Fuel	Oil
Diameter, first ring, inside	82 7/16 in.
Firebox, length and width	121 1/16 in. by 90 in.
Combustion chamber length	75 in.
Tubes, number and diameter	223—2¾ in.
Flues, number and diameter	45—5½ in.
Length over tube sheets	21 ft. 6 in.
Grate area	75.7 sq. ft.
Heating surfaces:	
Firebox and comb. chamber	350 sq. ft.
Tubes and flues	4,201 sq. ft.
Total evaporative	4,551 sq. ft.
Superheating	1,162 sq. ft.
Comb. evaporating and superheating	5,713 sq. ft.
Special equipment:	
Brick arch	Yes
Superheater	Type A
Feedwater heater	Worthington
Booster	Yes
Tender:	
Style	Vanderbilt
Water capacity	12,000 gal.
Oil capacity	4,000 gal.
General data estimated:	
Rated tractive force, 85 per cent	57,510 lb.
Rated tractive force with Booster	67,660 lb.
Cylinder horsepower (Cole)	2,965
Boiler horsepower (Cole) (est.)	3,067
Weight proportions:	
Weight on drivers ÷ total weight engine, per cent	66.8
Weight on drivers ÷ tractive force	4.28
Total weight engine ÷ cylinder hp	124
Boiler proportions:	
Boiler hp. ÷ cylinder hp., per cent	103.4
Comb. heat surface ÷ cylinder hp	1.93
Tractive force ÷ comb. heat. surface	10.07
Tractive force × dia. drivers ÷ comb. heat. surface	736
Cylinder hp. ÷ grate area	39.2

A Review of Power Brake Operation and the Results Obtained on the Southern Pacific

Developed in Testimony Before the I. C. C. by Julius Kruttschnitt, Chairman of the Board, Southern Pacific Company

The Southern Pacific has had perhaps longer and more extended experience in the use of air brakes on heavy grade lines than any other road in the United States. The Southern Pacific was one of the first, if not the first, companies to use air brakes on all of its equipment, both passenger and freight; the following is taken from Central Pacific annual report of 1883:

"For safety, not only to the company's property, but that entrusted to its care, it was decided to equip all freight cars with the new Westinghouse automatic air brakes."

This was over 40 years ago.

The Southern Pacific Lines afford about as severe a test of air brakes as can be found on any heavy-traffic line. Its main line of heaviest traffic between Sacramento and Ogden embraces grades of from 2 per cent to 2.5 per cent over the Sierra Nevada mountains; grades of 3.3 per cent are encountered on the main line over the Siskiyou mountains on the line from San Francisco to Portland, Oregon; while on branch lines grades of 3.8 per cent, or 200 feet per mile, are found. Grades of 2.5 per cent must be surmounted over the Tehaohapi mountains on the main line from San Francisco to Los Angeles, and grades of over 2 per cent are likewise met with on the main line from Los Angeles to El Paso. In fact, through traffic cannot be taken into San Francisco on any of the three routes —Ogden, Shasta or Sunset—without passing over gradients of at least 2 per cent. The mileage of very heavy grades on Pacific System lines is as follows:

1. % to 1.5%	471.53
1.51% to 2.0%	216.67
2.01% to 2.5%	180.08
2.51% to 3.0%	34.19
Over 3.0%	38.70
Total	941.17

The service record of the power brakes on 10,730 miles of all tracks of the Pacific System of the Southern Pacific is reflected in statistics of operation of 1922 and 1923, shown on Exhibit "A" herewith. No accident to any train, either passenger or freight, resulting from loss of control through brake failure occurred in these two years. For the years in question operated mileage of total tracks was 10,730 and 10,600, respectively. No passenger was killed in any train accident, and the total of all persons killed in train accidents was 52 and 41, respectively, in running 39,259,754 and 34,762,526 train miles in the respective years. The cost per train miles per accident from 1.70 cents in 1910 to 1.5 cents in 1923, or in prices adjusted to index number of 1910, from 1.70 cents to 0.98 cents.

The statement to which I refer is included in the tabulation Exhibit "A."

In response to Interstate Commerce Commission Order 13528 it was shown that on the Pacfic System lines, which are those with heaviest grades, the entire property damage during 1921 that can be charged to air brakes amounted to only $160. This damage resulted from four cases of burst or parted air hose, 23 of undesired quick action of brakes, and one to faulty manipulation of brakes. There were but 30 injuries, with no fatalities. This is a remarkable showing for any power brake system when it is remembered that 34,572,336 train miles were operated on the System during the year referred to, the ratio of train mileage to failures of air brakes being 1 to 1,234,000, or 50 times around the earth at the equator. As stated, there were no accidents caused by loss of control of trains in 1922 and 1923, although train mileage increased to 39,259,754 in 1923.

From the above it will be seen that so far as the Southern Pacific Lines are concerned, there is absolutely no reason for making any change whatever in the brake system now used.

I want to repeat that these statistics refer to the Pacific System of 10,700 miles on the Southern Pacific Company; that is, the lines west of Ogden and El Paso and south of Portland, on which lines are the heavy grades. The lines east of El Paso have very moderate grades, and the Commission has asked Mr. Scott, the president of those lines, to appear before it, and he will make his statement as to those lines.

How the Southern Pacific's remarkable record with power brakes was established is briefly outlined as follows:

All of our heaviest freight locomotives received since 1910 have two of the largest air compressors and reservoirs of 100,000 cubic inches capacity. The latest features of Westinghouse brakes have been adopted for passenger cars, which are being equipped; the work is not yet complete. All of our freight cars are fully equipped with A. R. A. standard equipment,

SOUTHERN PACIFIC COMPANY
(Pacific System)
"Exhibit A"

	Calendar Year 1923	Calendar Year 1922	Fiscal Year ended June 30, 1910
Miles of track	10,730	10,600	8,907
Passengers killed in train accidents (steam lines)	0	0	0
All persons, excl. trespassers, killed in train accidents (steam lines)	6	6	16
All persons, excl. trespassers, injured in train accidents (steam lines)	52	41	204
Total injuries to persons and property	$589,033	$665,724	$511,795
Total train mileage—passenger, freight, mixed and work service	39,259,754	34,762,526	30,081,550
Cost per train mile	1.500c	1.915c	1.701c
Bureau of Labor Statistics index number of commodity prices	154	149	101
Cost per train mile adjusted on basis of 1910 commodity prices	.984c	1.298c	1.701c

and that is the latest developed and perfected Westinghouse equipment.

At no place on the System do we allow hand brakes to be used to control the speed of trains. All weak and wooden underframe cars are put on rear of freight trains. We do not use chains in cases of break-in-twos except to get the car to some place to turn or switch it out.

On the 3.3 per cent grades over the Siskiyou mountains the safe load allowed per operative standard air brake is 45 tons. This duty per brake is fixed by the Motive Power Department, is based on speed that freight trains are allowed to make, and the rate of grade. The tonnage per operative brake is fixed consideratively low, so as to provide a reasonable factor of safety. Freight trains over the Siskiyou are hauled by four locomotives of the 2-10-2 class, with 75,100 pounds tractive power each, and the maximum gross train load drawn by these locomotives is 2,400 tons. The length of train, therefore, would be determined by the number of times 45 tons (the duty per brake) is contained in 2,400 tons, or 53 cars. That, I would say by way of explanation, is the minimum number of cars allowed, because it is determined by the number of tons that one operative brake can control.

Passenger trains on this grade consist of 13 cars handled by two locomotives of 75,100 traction each.

On the Sierra Nevada 2.2 per cent grades the tonnage per operative brake is 55 tons. The maximum train load is 2,450 tons. The average number of cars, therefore, is 2,450 divided by 55, or 44. Freight trains are handled by two Mallet consolidation locomotives of 94,000 pounds tractive effort each and one consolidation of 54,000 tractive effort. Passenger trains consist of 14 cars, handled by two Mikado locomotives of 51,000 pounds tractive power each.

Over the San Gorgonio Pass the tonnage per operative brake is 62½ tons. Maximum freight trains are 2,750 tons, which divided by 62½ tons, gives an average of about 40 cars per train. Two 2-10-2 class locomotives, 75,100 tractive power each handle the freight trains, and the passenger trains of 14 cars are handled by one Mountain class passenger locomotive, 66,000 pounds traction, helped by one Mogul of about 35,000 pound traction.

On all of the above grades the maximum power of all the locomotives is utilized up hill. In running down hill all locomotives except one are disconnected from the train, and the one locomotive handles all brakes on the entire train.

Engines are placed in freight trains as follows:

On the Siskiyous: One 2-10-2 the head-end of the train; 3 coupled together in the rear, ahead of the weak construction cars with the tonnage of one locomotive behind the three.

On the Sierra Nevadas: One Consolidation and one Mallet coupled at the head-end, and one Mallet in the rear of the train ahead of weak construction cars, or about 75 per cent of the tonnage for one Mallet.

On the San Gorgonio: One engine at the head-end and one back to the rear, with 75 per cent of its tonnage behind it, or ahead of all weak construction cars.

The maximum weight of single freight cars handled is ordinarily 53,000 pounds with a load of 116,000 pounds, total 169,000 pounds. Occasionally, however, a car weighing 50,000 pounds will have a load of 160,000 pounds, total 210,000 pounds. On construction work, hauling 45,000 pounds have been loaded with 204,000 pounds, total gross weight of car and contents 249,000 pounds.

On grades of 1.8 per cent and less there is no restriction to the load coupled behind a locomotive within its power to haul it, such train being built up of everything the locomotive has a capacity to pull at the required speed. On moderate grade and valley lines, trains of 100 cars are commonly hauled, and trains of 120 to 130 cars are by no means unusual.

Maximum train line pressure allowed in practice is 90 pounds, but the prescribed standard is 80 pounds for freight trains and 90 pounds for passenger trains; pressure in main reservoir in passenger trains 125 pounds and freight trains 115 pounds. Main reservoir pressures are thus 35 pounds and 45 pounds, respectively, above train line pressure. There is no special adjustment for brake power on high capacity cars.

The capacity of the brakes, or number of pounds of pressure of the brake shoe on the wheels, is proportioned to the light weight of the car. As the load on the car increases the percentage of brake power to gross weight of car and contents decreases, and would finally reach a danger point where the brake on the car could not control it, and for this reason the duty imposed on a single brake on the different grades is prescribed by the Motive Power Department, as illustrated above in the notes on the three principal grades of the system. There are two short grades, however, one on the Stirling Branch and one on the Klamath Falls Line, of 3.8 per cent, where the duty imposed on a single brake is confined to 40 tons.

Following are methods of inspection by which Southern Pacific maintains its high standard of air brake practice.

Air brakes on all locomotives are thoroughly inspected and tested upon arrival at all roundhouses, all defects corrected and again tested before departure.

After a freight train is made up the brake system is charged with air from the yard line, brake pipes are inspected for leaks, angle cocks and hose are given soapsuds test while charged to standard pressure and any found leaking must be replaced with perfect ones, 94,000 hose being replaced in 1922, piston travel is adjusted and brake rigging placed in first class condition and retaining valves are tested. The tests on retaining valves are made at 10 points on the system; the other tests are made at all terminals, 18 in number.

When locomotives are attached, brakes are applied by the engineer. Inspectors examine the brakes under each car, and all must be operated from the engine before train is permitted to depart from any terminal.

In addition to the above freight train tests, the engineer of a passenger train is required to apply a service test to the brakes after he has the train moving at a speed of 8 to 10 miles per hour without shutting off steam. If he feels the brakes apply he can, before the train is stopped, release them and proceed. While this test is being made the rear brakeman is required to station himself at the retaining valve on the last car in the train, and if the brakes set and release on that car properly, he gives a "proceed" signal to the engineer. The air brake rules of the company cover this requirement.

Any triple valve in service, 12 months or more is replaced by one cleaned and tested on a standard triple valve test rack in accordance with American Railway Association requirements. One of these racks is located at each inspection point, there being 18 on the system. Locomotive brakes are tested at 14 points with test racks equipped with the latest improved apparatus. All brake cylinders are cleaned and lubricated every 12 months. Should any defect develop in the brake system between repair points, the conductor is required to note it on a prescribed form and hand it to the car foreman at the first repair station. Car inspectors and trainmen are required to look over trains carefully for leaks and other defects at every opportunity. Rear end test is made whenever the train pipe has been separated from any cause, whether for locomotive cutting off for water, air brake hose uncoupled for switching, etc., and is made by the rear brakeman turning the angle cock at the end of the train to make sure that the integrity of the train line has been restored, and that the air is traveling freely from the locomotive to the last car of the train.

To guard against accidents from overheated wheels, trains are equipped to stop 10 minutes after runs of 5 to 8 miles on heavy grades, to permit the diffusion of heat in the wheels, that is, to reduce the temperature spread between the hubs and the treads of the wheels. Thre are 53 of these cooling stations on the system.

The Southern Pacific maintains its power brake equipment on both passenger and freight cars in the highest state of efficiency, and as proven improvements are placed on the market it adopts them with all reasonable speed in order to conform to its general policy to make the operation of its properties as safe as possible through the exercise of foresight and provident expenditures.

Our policy on improvements is this: We are approached all the time by inventors of new devices who make claims for them. If the claim is unsupported by tests to prove its ability to do what is claimed for it, we ordinarily pay no attention to it. Or if we cannot be given the experience of some road that has already used it, in which case we take the advice of that road, and if it has been successful on that road and it seemed of sufficient importance to adopt, we make tests ourselves at our own expense, and, if successful, we adopt it.

For instance, we are intensely interested in the development of a locomotive with an internal combustion engine, the most successful of which is the Diesel engine. In the last four or five months I have received communications of the promoters of this engine making the most extravagant claims as to what it can do. And upon investigation in both of these cases the claims were found to be based simply on sketches and diagrams and the opinion of the inventor as to what it would do. In pursuing the investigation we find that money is wanted. They propose that our company shall assume the expense of developing their device and proving it, and then, of course, if it is successful, to buy it from them. Our answer to that is that, "If you want to perfect your device do it yourself; and when you have it perfected bring it to us, and if its merit is proven we will no doubt want to adopt it."

With unproved devices, or devices as to which the experience of some other road which has used the device successfully and that is not shown, we pay no attention to it.

We are members of the American Railway Association, but we do not depend altogether upon what they do, and while we have made no special experiments in the line of emergency applications of brakes as has been suggested, but in an experience of nearly forty-one years we have never heard that to accomplish that is of any particular importance. And the small importance of accomplishing that is proven by the fact that in the three years in question we have run in freight trains over 100,000,000 of train miles, and we have never yet had brought to our attention the great necessity of accomplishing what you mentioned. The freight train division averages somewhere around 125 miles, so the number of trains run would be the quotient of 125 into more than 100,000,000. In other words, it would be somewhat less than a million trains. And in running that actual number of trains we have never been confronted with the necessity of doing what it is claimed this new brake can do. In other words, the claim that this brake will do something, even if substantiated by absolute proof, would be to us not a sufficient reason for adopting it, for the reason that we understand the cost of these brakes in comparison with the Westinghouse brakes is very high, and never having experienced the necessity for this particular feature we hesitate very much to assume an expense which, we understand, runs from $150 to $160 a car for the attachments merely, in addition to the $65 or so that it requires to equip a car with the most perfect type of Westinghouse brake that we are using. On the roads of the country it would be an expenditure of several hundred millions of dollars.

I have with me our Southern Pacific air brake inspector. On the trip over I was quizzing him as to various things that might have happened on the road, and he told me of this incident. His business is to ride the trains of the road pretty much continuously, and recently on one of the heaviest grades the engineer, who was an old experienced engineer, made an application of the brakes under the conditions that you mention. He was going down grade and for some reason undertook to put on the emergency, and gave a terrific shock to the train. Whereupon, the air brake inspector went up to the head-end and said, "What is the matter? Why did you make such a bad stop here?" "Oh, well, the cars are out of order. The brakes are out of order."

And the air brake inspector said, "Perhaps you did not know it, but I have been riding this train behind you for a hundred miles, and you made perfect stops up to this point. Now, what happened so suddenly to the cars?"

The man was stumped. After giving him instructions indicating what he had done wrongly, he proceeded with his run, and every stop was perfectly made thereafter.

What One Railway is Doing to Insure Safety to Passengers

How train accidents caused by "man failure" are prevented on the Pennsylvania Railroad System is shown in a report just issued by the chief of transportation. This report covers what are known as "efficiency" tests to determine whether employes engaged in train movement are properly observing signals, operating rules and other safety precautions.

Results of these tests show consistently as high as 99.9 per cent efficiency on the part of employes to whom the tests were applied.

Under the plan in effect on the Pennsylvania, thousands of these tests are made every month. Their purpose is to insure as far as possible the actual observance of safety rules and devices by the men in charge of trains while they are out on the road.

Each operating division is required to make a minimum number of tests every month based on the number of locomotives operated and the number of miles they travel. In the last half of 1923, 300,000 tests were required, but the number actually made totalled more than 493,000.

The plan is designed to cover not only ordinary operating conditions, but also surprise situations not usually met by a train crew in its daily run. In carrying out this plan complete precautions are taken to avoid interjecting any element of risk in the conduct of the tests themselves, or in their results.

The employes subject to the tests are: enginemen, firemen, conductors, brakemen, flagmen, trainmen, signalmen, agents, yardmasters, car inspectors, switch tenders, trackmen and watchmen.

Under this system a constant check is made of the observance of rules and steps are taken immediately to correct lapses and to prevent future "failures." It is a tribute to the employes, however, that the number of "failures" reported over many months is relatively insignificant.

Three Cylinder Superheated Steam Express Locomotive of the German State Railways

In a recent issue of *Die Locomotiv* there was published a description of a three-cylinder express locomotive that has been used somewhat extensively on the German State Railways. The first engine of this type was built at the Borsig shops in Tegel in the Spring of 1922 and since that time a number of others have been put into service in southern Germany and in Saxony where they are used in the same service as the four-cylinder compound locomotive.

The German argument against the use of the two-cylinder compound locomotive is based upon two points.

The first is that when the second axle is used as a driver, and the engine is running backward the vertical component of the thrust of the main rod, with a cylinder pressure approaching 100,000 lbs., is sufficient to almost entirely counteract the weight of the wheel on the rail. Whereas if the third axle were to be used as a driving axle, it would necessitate either a twelve-foot length of main rod or a greatly increased length of piston rod; both of which are undesirable. Attention, however, is called, in the article to the fact that, on some American two-cylinder compound locomotives a cylinder pressure or more than 12,000 lbs. are used.

On the other hand with the three-cylinder engine a triple driving gear is required, but it increases the evenness of the turning moment by about 6 per cent. Still there is the disadvantage of a complete inside driving gear.

It is well known that, in England, the three-cylinder engine was somewhat extensively used, while the Americans, at the time of the introduction of the compound engine, pinned their faith almost exclusively to the two-cylinder type.

As for the crank axle, it is necessitated by the three as well as by the four-cylinder types, and with but little difference in cost. As a point of comparison the three-cylinder locomotive with cylinders 20½ in. in diameter is the practical equivalent of a two-cylinder locomotive with cylinders 25 in. in diameter, and this corresponds to American locomotives having about 162,000 lbs. on the driving wheels.

It is this type of three-cylinder locomotive under consideration that has been in use on the State railways and while doing well requires that a considerable inclination be given to the central cylinder, which necessitates an intrusion into the bottom of the smokebox, thus forming a pocket for which a drain valve must be provided.

In this engine the boiler shell is 72 7/16 in. inside diameter, which is 2 in. larger than the boiler of the corresponding Hartman locomotive. The thickness of the plate is ¾ in. The smokebox is very long (9 ft. 6¾ in.), and the distance from the tube-sheet to the center of the stack is 5 ft. 5⅝ in. The boiler has two domes, the one at the rear contains the throttle valve and the front one an apparatus for purifying the feed water. The sandbox is placed between them and is fitted with a Knoss sander; sand being applied to the rails in front of all of the driving wheels.

The firebox has the usual vertical back tubesheet and sloping back head, and is set with its throat sheet 13¾ in. ahead of the center of the rear driving wheel, which, because of its being narrow at the front makes it possible to shorten the boiler about 3 ft. 7¼ in. The boiler is of the Belpaire type, with a large firebox and heating surface and ample water space. The grate slopes one in fifteen from the back down to the front.

The front row of stays are set in the deep flange of the rear tube sheet, which is of copper and 1 in. thick. This row together with the next and the top row are of manganese bronze, while the balance are of copper.

The feed water is led into the water purifying apparatus in the front dome, where it falls upon a grating made of angles, upon which the greater portion of the impurities are deposited. It then falls into troughs arranged along the side of the boiler, and any further deposition is washed into the mud drums.

The boiler is equipped with the Schmidt superheater and, on the top of the superheater header there is an air valve by which the superheater units are cooled when the throttle is closed, or it may be used to admit warm air into the cylinders. This valve is now in general use.

The frames are of the bar type and are extended back to the trailing wheels where it is attached to the plate frame, an arrangement that permits of 3 15/16 in. lateral motion for the trailing wheel. All of the springs, with the exception of those on the engine truck are underhung, and they are in two groups, each group being connected with equalizers.

The front truck is of the Krauss-Helmholtz type and permits of a movement of 2 15/16 in. for the center pin and a side play for the axle of 4 15/16 in. with an initial side spring thrust of 550 lbs. and a final thrust of 1,892 lbs. The same statement applies to the trailing wheels. The front driving wheel has a play of 1 3/16 in. on each side. The main driver has no side play but its tire has a flange that is 9/16 in. narrower than the others. The third driver has a play of about 1 in. on each side and its axle carries the eccentrics. On the right side there is but one, while on the left side there are two, one being for the inside gear. The trailing axle is of the Adams type and is equipped with underhung springs.

Twenty-seven per cent of the weight of the reciprocating parts are counterbalanced by which the axle load is increased only 15 per cent when the speed is 62 miles per hour.

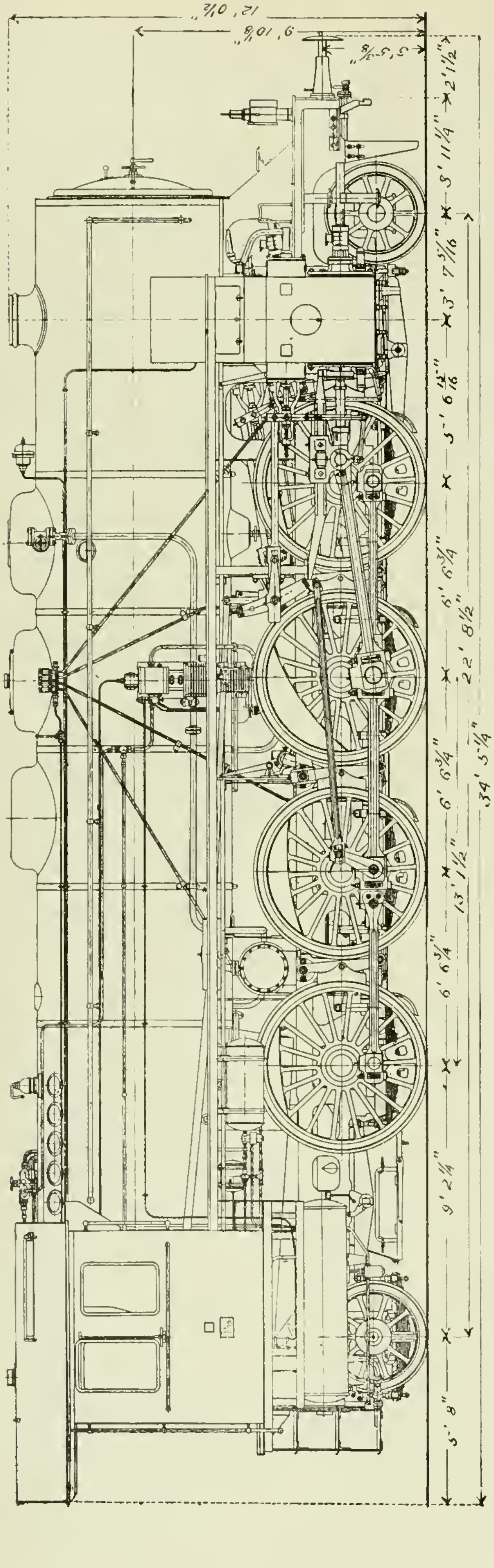
The front and back side rods are fitted with the Hagans type of ball joints.

The piston valve is of the inside admission type and is 8⅝ in. in diameter. The exhause pipe is well down under the center of the boiler. The diameter of the exhaust pipe is 5⅛ in. and that of the stack is 17 9/16 in. After an investigation had been made of these dimensions by the government it was found that instead of those given, it would be better to use a diameter of 6 5/16 for the exhaust pipe and 25 3/16 in. for the stack. This cut down the speed of the flow of the steam as well as that of the gases and also necessitated the use of a bridge ½ in. wide over the exhaust nozzle.

The more recent locomotives have air deflectors for reducing air resistances.

A two-cylinder brake is used for applying the brakes on the driving wheels all of which are fitted with shoes.

The tender is of the four axle type and has a water capacity of 8,320 gallons and a coal capacity of 7.7 tons. The weight in working order is 142,780 lbs. and 58,080 light.



Side Elevation of Three-Cylinder Express Locomotive for the German State Railways Using Superheated Steam

The total wheel base of the engine and tender is 63 ft. 7 5/16 in. and the machine can be turned on a 66 ft. turntable.

Running tests have been made between Charlottenburg and Lehrte with a 792-ton train, the distance being 145.7 miles, a maximum speed of from 62 to 74.4 miles per hour having been attained. The amount of work developed at the drawbar was at a rate of from 1,000 to 1,100 horse power per hour, and that with a steam consumption of about 24.2 lbs. per horsepower hour.

In the designing of this engine is was estimated that its best performance would be on grades of one per cent or more, but it has been found that it is also economical on a level track where the speeds attained sometimes run from 46.5 to 55.2 miles per hour.

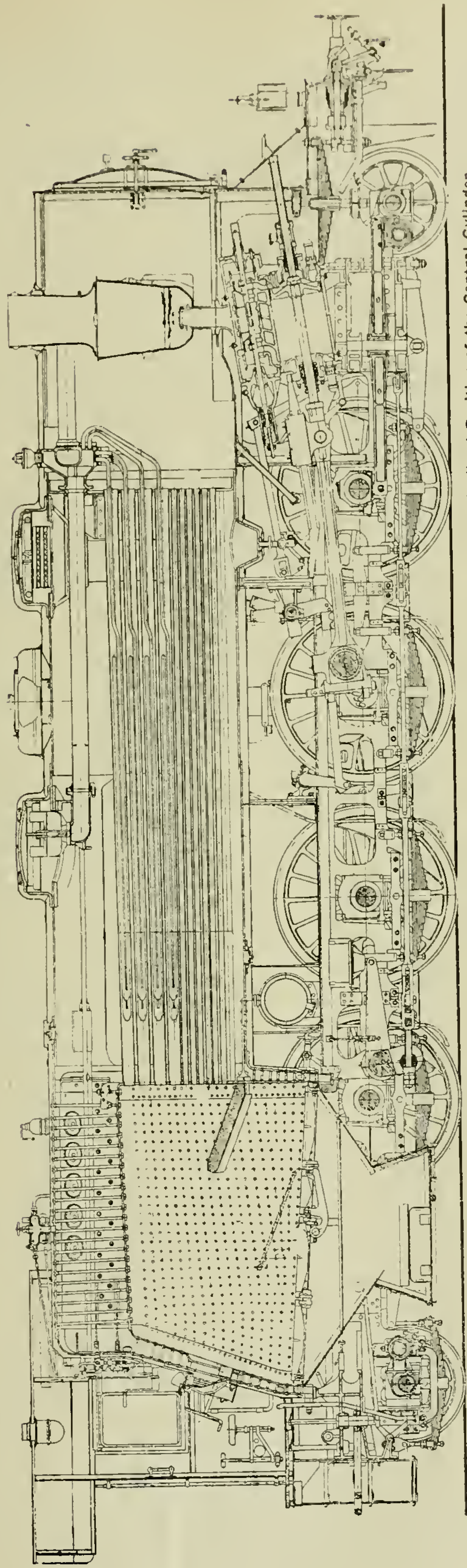
On one trip the test express train was made up of 65 axles with a total load of 792 tons. This run was made on the 145.7 mile stretch from Charlottenburg to Lehrte with a stop at Stendal, which is 62.6 miles from Charlottenburg. The trip was made in 174 minutes, or at a speed of 50.2 miles per hour. Before the war this was about the average speed at which the trains were run between these two places.

On this trip the coal consumption amounted to 11,880 lbs. which is equivalent to 83.2 lbs. per mile. The consumption of water was 8,326 gallons showing that the tender was to small for the demand that was put upon it. The usual run is 111.6 miles on which the water consumption is 7,397 gallons, while for the stretch from Stendal to Lehrte, 83 miles, the water consumption was 4,782 gallons. The consumption naturally varied on the four runs. On the first run it was the highest or 9,378 gallons for a speed of 46.5 miles per hour, while on the last and fastest trip when the speed was 55.2 miles per hour the consumption was 9,057 gallons. The coefficient of evaporation was six. The average draft on the smokbox was 5.5 in. of water. The smokebox temperature was 585° Fahr. and that in the superheater header was 640° Fahr.

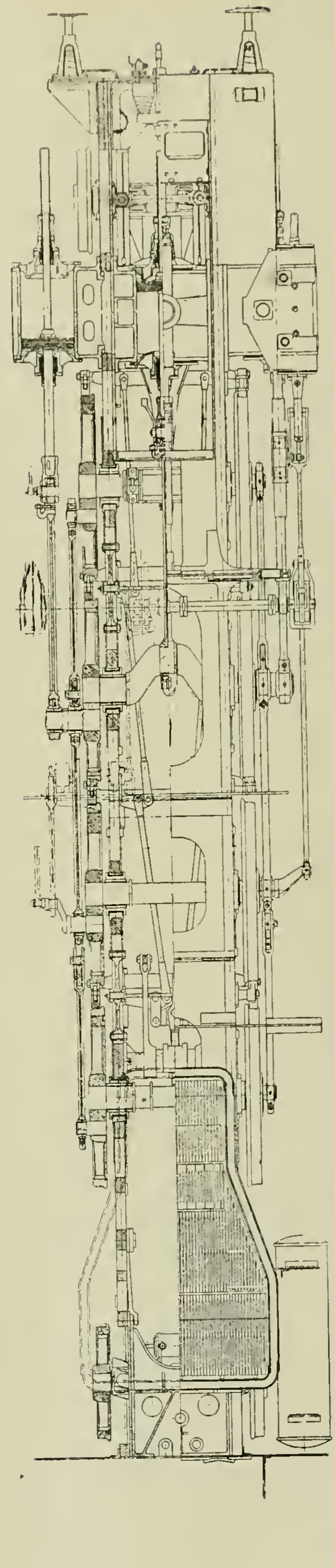
The last express test was made with a four-cylinder compound, with a train of 69 axles weighing 652 tons, on the stretch between Berlin and Hanover, where the speed of 60.7 miles per hour was attained. At the same time the later built three-cylinder engine was hauling a train of 75 axles weighing 765.2 tons at a maximum speed of 62 miles per hour.

On the trip between Gasten and Mansfield, 19.8 miles on a one per cent grade, the train was made up of 61 axles and weighed 621 tons, and here the average speed was 32.2 miles per hour and the temperature in the superheater header was from 605° to 625° Fahr. and there was a vacuum of from 4 9/16 in. to 4⅝ in. in the smokebox. The dynamometer reading at the drawbar at the rear of the tender ran from 910 to 988-horsepower per hour, with an engine cut-off of 37 per cent of the stroke and with a steam consumption of 26.4 lbs. per horsepower hour. The maximum readings at the drawbar were for a time, about 1,400-horsepower per hour. The indicated horsepower ran from 2,000 to 2,200 or from 46.4 to 51.1-horsepower per sq. ft. of grate area or about 0.65-horsepower per sq. ft. of heating surface.

On the Schwarzwald Ry. between Hansach and Sommeran, a distance of 21.7 miles with a rise of 1,930 ft. between the two places and an average grade of one in fifty-nine, or if the compensation of a 1,285 ft. curve is taken into consideration the grade becomes one in fifty-two. There are thirty-eight tunnels on the line, most of them being very damp which added to the difficulties of the trip. In spite of these handicaps the locomotive, using well broken coal, hauled a train of 340 tons at an average



Longitudinal Section of Three-Cylinder Express Locomotive for the German State Railways, Showing the Inclined Position of the Central Cylinder



Sectional Plan of Three-Cylinder Express Locomotive for the German State Railways Showing the Contraction of the Front of the Firebox and the Crank Axle speed of 27.3 miles per hour, and with a drawbar pull of 1,025 horsepower per hour or with an efficiency of about 50 per cent as the indicated horse power was about 2,000.

At a maximum speed of 27.9 miles per hour the evaporation was at the rate of 14 lbs. per sq. ft. of heating surface, and the temperature went up to 682° Fahr. in the superheater header and to 663° Fahr. in the steam chest.

On a grade of one in forty between Probstzelle and Steinbach and between Rothenkirchen and Steinbach the run was made at speeds of from 15.5 to 18.6 miles per hour with a drawbar pull of about 900 horsepower per hour and with a continuous tractive effort of from 19,800 to 22,000 lbs. This entire train of 616 tons was not pulled in the direction of Nurnberg but only from 330 to 350 tons of it. No record was made of this trip.

The following are the principal dimensions of this engine:

Cylinder diameter	20½ in.
Piston stroke	25½ in.
Diameter front truck wheels	38⅜ in.
Diameter driving wheels	68⅞ in.
Diameter trailing truck wheels	43 5/16 in.
Distance front truck wheel to front driving wheel	9 ft. 2¼ in.
Driving wheel base	19 ft. 8¼ in.
Rigid wheel base	13 ft. 1½ in.
Distance between rear driving wheel and trailing truck wheel	9ft. 2¼ in.
Total wheel base	38 ft. ¾ in.
Center of boiler above top of rail	9 ft. 10⅛ in.
Inside diameter of boiler	72 7/16 in.
Number of tubes	143
Diameter of tubes (inside and outside)	2 in. & 2 3/16 in.
Number of flues	34
Diameter of tubes (inside and outside)	5 in. & 5¼ in.
Length of tubes	19 ft. ⅜ in.
Boiler pressure	206 lbs. per sq. in.
Heating surface firebox	193.65 sq. ft.
Heating surface tubes	2,183.95 sq. ft.
Heating surface total (firebox and tubes)	2,387.60 sq. ft.
Heating surface superheater	1,082.19 sq. ft.
Heating surface total	3,469.79 sq. ft.
Grate area	43.03 sq. ft.
Weight light	191,400 lbs.
Weight in working order	205,600 lbs.
Weight on drivers	149,600 lbs.
Total length (without roof)	46 ft. 7 1/16 in.
Total width	10 ft. 2 1/16 in.
Total height	12 ft. ½ in.
Maximum tractive power	37,840 lbs.
Maximum tractive speed	74.4 miles per hour
Tender type	4 axled
Diameter of wheels	39¾ in.
Wheel base	18 ft. 4⅜ in.
Water capacity	8,320 gallons
Coal capacity	7.7 tons
Weight of tender light	51,700 lbs.
Weight of tender in working order	138,160 lbs.

In the arrangement of the wheel of the locomotive the wheels of the front truck are given a clearance of 5 in. The front driving wheel has a side play of 1-3/16 in; the third driving wheel has a side play of 1 in.; the main driving wheel has a tire that is 9/16 in. thinner than the standard and the rear trailing wheel has a clearance of 4 in.

Air Brake Association Convention

The 31st annual convention of the Air Brake Association will be held May 6, 7, 8 and 9 at Montreal, Canada, and the Mount Royal Hotel has been selected as the convention headquarters, where suitable convention halls, together with ample exhibit space, have been arranged for. A wholesale entertainment schedule is now in the making by the entertainment committee, and will include motor excursions to nearby points of interest on Mount Royal, and around the many beautiful drives of the St. Lawrence River, as well as a journey to the shrine of St. Anne de Beaupre and Montmorency Falls. In connection with the convention the Air Brake Appliance Association will hold an exhibit, the latter being confined this year to small unit exhibits instead of heavy working appliances.

Fuel Conservation Contributes to General Efficiency in Railroad Operation

By W. E. Symons

In previous issues we have presented for our readers certain data intended to aid those interested in fuel conservation alone or in the general or broader question of a higher standard of operating efficiency in railway management.

The following tabulation of statistical data of 40 railways contains much food for thought which it is hoped will serve as a stimulant to those who are, or should be, actively working along conservation lines on this problem.

Some of these items present such a wide range of results as to invite study, reflecting as they do the correspondingly wide range of difference under which the respective lines operate, diversity of fluctuation of traffic, and other factors which influence results.

The average cost of repairs per engine per year, it will be noted, does not follow the size of engines as shown by the average tractive power, or the net revenue tons per train hauled, as some might expect, but is no doubt influenced by prices of labor, shop facilities and the physical condition of power with respect to deferred maintenance.

One or two examples may serve to emphasize this feature.

The Pittsburgh & Lake Erie with engines of 44,060 pounds tractive power, train load of 1,359 net revenue tons and earning of $129,598 per mile of road, maintained their engines for $4,998 each, while the Chicago & Alton with engines of only 35,909 pounds tractive power, train load of only 569 tons and earning $26,267 per mile, spent $8,238 each in repairs to locomotives. These figures should not be construed as any reflection on the Alton management or the head of their machinery department as the cost of maintenance may reflect adverse labor and shop condition plus deferred maintenance.

The New York Central and Pennsylvania afford two examples of through trunk lines that while doing a heavy passenger business, also have a high rating per revenue tons of freight per train, earnings per passenger train mile, earnings per road mile and in cost of repairs of engines the slightly higher cost per year on the Pennsylvania reflecting as it should the physical characteristics of the country through which they operate.

Quantity of Coal Used and Cost

In the matter of coal used per unit of service the same wide range of differences are found and may in most cases be explained in the same manner, although it would appear that in the items of;

(a) Pounds of coal per 1,000 ton miles and per passenger car mile.

(b) Average engine and car miles per day and,

(c) The average hours per day that engines are actually running, thus producing freight ton miles or passenger miles, that there is room for much improvement.

The locomotives on our railways which represent an investment of many hundreds of millions of dollars should *Work More* and *Loaf Less*. And if this or any other article on this subject should even in a small degree aid in this matter we will feel amply repaid for our effort in spreading the gospel of a higher efficiency in railway operation.

1922	GENERAL						FREIGHT - STATISTICS									PASSENGER - STATISTICS							1922 Ratio
	Name of Railway	Mileage - Engines in Service - Average Tractive Power - Cost to Repair - Earnings per Mile																					
		Miles of Road	Engines in Service	Average Tractive Power	Annual Cost of Repairs	Earnings per Mile of Road	Train Load Revenue & Non-Revenue Net-Tons	Train Speed Miles per Hour	Aver. Haul in Miles	Pounds Coal Per 1,000 Ton Miles	Cost of Coal per Ton	Rev. per Frei't Train Mile	Aver. Car Miles per Day	Aver. Engine Miles per Day	Per-cent of Fr't. Rev.	Pass. Train Cars per Train	Aver. No. of Passengers per Train	Aver. Journey in Miles	Pounds Coal Per Pass. Car Mile	Rev. per Pass. Train Mile	Aver. Loco. Miles per Day	Per-cent Passenger Rev.	Operating Expenses to Earnings
1	At. Coast Line	4,860	889	27,779	$ 5,218	$14,598	470	12.4	184	133	$4.23	$6.15	31.6	62	69.0	7.2	51.7	72.6	14	$2.21	99.3	22.4	73.5
2	A. T. & S. Fe	9,722	1,627	42,210	9,029	20,548	574	12.9	323	145	3.65	7.07	45.9	74	69.7	7.9	67.7	169.7	15.7	2.89	128.1	22.0	73.9
3	B. & O.	5,212	2,480	43,780	8,673	39,534	798	9.4	191.6	190	3.24	8.06	28.	50	79.4	6.7	49.5	56.1	19.2	2.14	108	13.3	79.4
4	Bess. & L. E.	228	198	43,756	5,496	64,348	1,402	10.4	108		3.83	10.72	13.	44	95.4	3.7	24.8	17.8		1.06	81	2.6	69.5
6	Boston & Maine	2,286	1,090	28,225	6,474	35,584	444	10.2	126	185	6.10	7.83	16.9	48	60.5	5.5	87.7	30.2	22.5	2.97	70	28.3	84.0
6	Cent. of N. J.	694	593	32,030	6,212	70,552	648	8.5	66.4	207	5.47	11.34	10.8	42	73.8	4.9	108.3	16.0	30.6	2.60	76	19.3	85.8
7	Chicago & Alton	1,050	341	35,909	8,238	26,267	569	11.1	177	209	3.36	5.65	21.4	64	69.0	6.0	56.8	76.9	16.8	2.40	98	22.0	85.7
8	Chicago C. W.	1,496	275	38,780	8,175	16,192	648	12.2	295		4.40	6.04	27.7	60	73.2	5.7	43.0	83.2		1.88	140	18.0	87.8
9	C. M. & S. P.	11,025	2,094	35,596	6,050	11,750	628	11.3	252	171	4.10	5.94	26.8	54	74.0	6.1	43.0	74.0	18.6	2.02	97	15.6	82.6
10	C. B. & Q.	9,393	1,925	35,394	6,121	17,568	727	11.9	300	181	3.72	6.49	30.7	57	73.6	6.6	53.3	72.0	19.3	2.16	111	17.2	76.9
11	C. & N. W.	8,403	2,045	32,209	5,490	17,385	512	11.8	156	184	3.48	5.72	21.8	49	69.2	6.3	60.1	63.2	22.3	2.23	95	20.0	81.6
12	C. R. I. & P.	7,635	1,157	32,826	5,564	15,572	509	11.9	253	201	4.09	5.44	29.	58	69.8	5.2	54.9	76.8	21.3	2.16	106	22.8	80.3
13	C. & O.	2,550	943	45,997	6,613	32,761	1,249	8.8	268.6	150	3.60	8.19	23.	48	82.2	5.6	58.1	46.7	21.4	2.44	98	12.7	79.2
14	Del. & Hud.	886	489	40,333	7,111	42,535	804	9.7	182	228	3.79	8.21	23.2	48	81.6	5.4	49.4	34.3	25.8	2.26	87	10.0	94.1
15	D. L. & W.	953	790	35,023	8,788	78,234	717	10.8	178	218	5.59	9.30	27.4	61	69.0	7.2	112.1	42.6	19.9	3.22	112	18.8	85.3
16	D. & R. O.	2,604	578	33,881	5,230	12,860	604	9.3	171	276	2.96	8.40	16.1	37	75.1	7.1	66.4	174.	23.3	2.48	79	16.7	78.9
17	D. M. & Nor.	305	118	46,487	4,944	48,875	1,569	15.2	70.4		5.41	17.20	14.	35	88.8	4.0	33.3	47.3		1.39	95	2.8	50.4
18	D. T. & Iron.	454	74	36,804	17,705	19,806	839	8.5	118.8		4.13	8.69	26.8	62	96.9	2.6	14.8	29.0		.68	100	1.4	83.3
19	Erie	2,438	1,365	40,971	9,999	46,277	878	10.4	228.5	164	4.46	7.93	26.3	46	71.1	7.3	83.5	35.6	22.1	2.41	84	13.0	93.7
20	Great Nor.	8,255	1,420	39,166	4,114	12,523	781	10.3	250.7	183	5.40	7.44	22.9	41	75.5	6.2	39.5	86.3	19.5	1.93	96	14.6	77.0
21	Hocking Val.	348	170	45,401	9,066	39,722	1,431	9.0	117.2		3.59	11.34	10.9	36	84.0	4.1	49.9	47.8		2.13	96	7.8	82.1
22	Ill. Cent.	6,164	1,725	37,390	7,225	28,345	761	11.3	290.1	154	3.16	6.10	38.7	75	76.9	6.0	53.6	46.3	19.7	2.07	123	16.3	77.8
23	L. & N.	5,036	1,279	35,535	7,936	24,042	540	11.0	210	193	2.59	4.98	27.7	81	74.8	5.8	55.5	54.9	20.7	2.34	139	18.8	82.2
24	Lehigh Val.	1,335	1,014	38,659	8,317	46,754	760	11.4	193	217	5.04	8.44	16.3	37	81.1	7.7	53.0	71.6	20.9	2.49	80	11.3	94.6
25	Mich. Cent.	1,862	800	36,772	5,502	44,803	678	13.3	153	136	5.35	8.91	27.7	45	66.8	9.0	81.9	125.4	13.2	3.70	129	23.1	71.4
26	Mo. Pac.	7,148	1,143	33,083	7,063	13,760	616	11.7	229	182	3.53	6.25	21.7	58	74.0	5.9	45.7	56.2	20.3	2.14	107	16.9	84.7
27	Nor. Pac.	6,631	1,438	36,600	3,266	14,468	711	12.5	281	143	4.68	7.10	25.9	43	74.7	6.8	48.9	92.8	18.2	2.10	89	16.2	75.6
28	New York Cent.	6,899	4,030	38,295	5,528	52,698	826	10.7	194	133	4.47	8.50	24.	47	62.7	7.8	86.6	82.1	14.8	3.45	96	25.3	80.0
29	Nor. & West.	2,237	1,069	49,901	8,814	40,357	1,166	10.8	279	238	2.31	7.89	31.	49	86.0	6.2	55.6	43.7	30.2	2.43	99	10.2	75.3
30	N. Y. C. & St.L.	1,242	280	32,427	9,349	31,728	614	12.8	204	150	4.61	6.34	43.7	68	92.1	5.3	32.3	83.6	18.6	1.40	95	4.0	77.2
31	New Haven	2,000	1,230	31,336	8,284	61,640	522	9.8	107.7	197	6.36	11.48	11.9	46	48.6	6.3	136.2	41.6	22.4	4.18	80	39.9	81.1
32	Penn. System	10,534	7,280	41,922	8,793	61,356	885			170	3.55	8.52		58	68.0	6.7			18.9	3.00	114	22.8	62.6
33	Phila. & Read.	1,125	872	38,214	5,109	72,112	825	10.4	99.1	190	4.45	10.03	18.7	51	82.3	4.6	66.8	23.3	30.3	2.11	77	12.1	75.7
34	Pitts. & L. E.	231	318	44,060	4,988	129,589	1,359	10.1	59.5	76	4.11	18.38	7.4	50	86.6	5.2	84.3	30.8	24.9	2.37	84	9.5	84.8
35	So. Pac. P. S.	7,116	1,515	38,431	7,887	25,258	663	10.9	282	159		9.21	36.6	62	65.9	8.2	69.8	53.8	13.3	2.59	112	24.3	69.5
36	Southern	6,971	1,700	38,293	5,295	18,432	481	11.4	153	218	3.09	5.65	21.4	43	68.6	5.8	57.2	61.8	22.2	2.37	102	23.4	75.6
37	Tex. - Pacific	1,952	364	32,729	7,201	16,071	529	10.4	178	189	4.97	7.48	22.8	40	69.3	6.5	63.0	84.5	18.7	2.70	104	23.2	81.2
38	Union Pacific	3,708	940	40,227	9,547	29,197	642	14.8	394.3	186	3.39	6.61	55.3	66	74.8	8.2	53.5	180.3	15.5	2.18	131	16.1	68.6
39	Wabash	2,472	618	33,715	8,779	23,317	656	12.9	251.5	165	3.57	6.72	31.7	56	76.2	4.7	47.7	85.8	18.4	2.08	127	15.8	83.3
40	Wheeling & L.E.	511	219	42,392	6,559	25,711	897	7.1	87.7		3.04	10.77	10.5	31	85.5	3.7	31.8	35.4		1.27	77	5.9	84.7
	Totals or Averages	155,971	48,493	37,808	7,191	36,050	772	10.9	195.4	179	4.12	8.31	24.8	52	75.2	6.0	59.7	66.8	20.4	2.31	100.5	16.4	79.8
	Tot. or Aver. U. S.																						

W. E. Symons. Feb. 1924.

A Tabulation for Comparative Purposes, Etc., Showing the Mileage, Engines in Service, Average Tractive Power, Annual Cost of Repairs, Earnings Per Mile of Road, with Freight and Passenger Statistics, and Operating Ratios for Forty Principal Railway Companies, with Totals and Averages.

Mikado Type Locomotives of Canadian National Railways

When considering the type and design of locomotive to proceed with for handling the increasing traffic of the Western Region, the Canadian National motive power officials decided on a Mikado type, with a Belpaire boiler, as that type of boiler permits of greater heating surface and steam space. Forty-five of these locomotives have been completed recently, 35 by Montreal Locomotive Works and 10 by Canadian Locomotive Company. All of them have been put into service on the Western Region and are especially designed for conditions in western Canada. The 10 built at Kingston are equipped with a booster on the the trailing axle, and except for the few changes made necessary on account of this application, are identical with those built at Montreal. A large number of the details used in the construction of these locomotives are the same as those of the previous order for Mikados and many of the details are common to all Canadian National modern power.

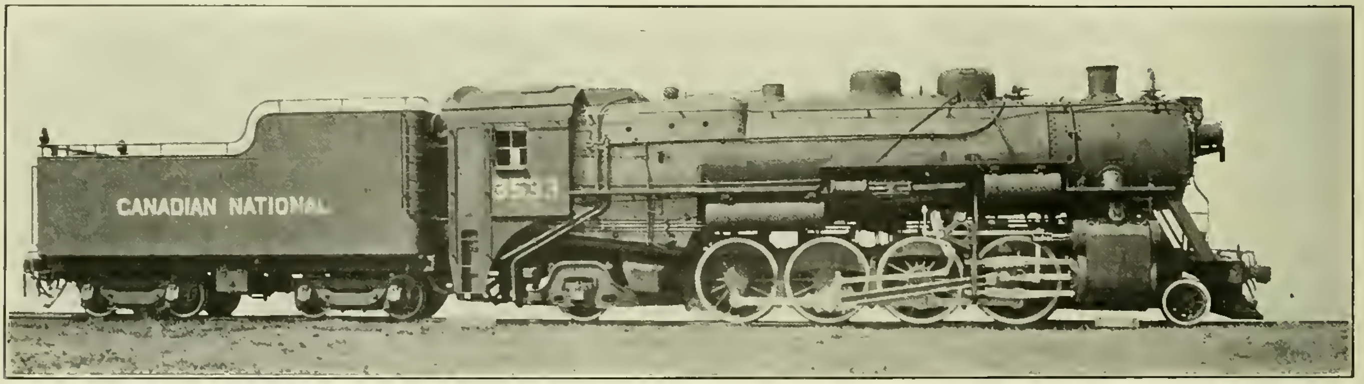
The locomotive without the booster are classified by the Canadian National as S-2-a and are numbered from 3525 to 3559 both inclusive. Those locomotives with the booster are classified as S-2-b and numbered from 3560 to 3569 both inclusive. The cylinders are 27 in. diameter by 30 in. stroke, driving wheels 63 in. diameter, and boiler pressure 185 lbs.

The boiler has a Belpaire firebox, and extended wagon top and conical bottom barrel, the first course being 78 in. and the large course being 90 in. outside diameter. The firebox proper is 84¼x108⅛ in. inside and the combustion chamber is 22½ in. long. The boiler horsepower in per cent of cylinder horsepower is 96 per cent. There are 240 2 in. tubes and 40 5⅜ in. flues 18 ft. long; the flues being electrically welded into back tube sheet as per Canadian National standard practice.

The fireboxes are provided with extruded side sheets. This form of side sheet is being developed on the Canadian National in an effort to overcome troubles due to bad water. With the ordinary flat side sheet, any hammering of the staybolts has a tendency to open up the sheet around the thread of the stay, until eventually nothing but the bat head of the stay is holding the sheet. The extended sheet is arranged so that any hammering of the stays will close the sheet in on the thread.

The locomotives are equipped with Duplex stokers and the feed-water supply to boiler is by means of a Worthington feed-water heater and pump on the left side, that on the right being supplied by a Hancock type E. A. inspirator, equipped with 3,500 gallon tubes.

The grates are of Canadian National standard design, the rocking grate bars being of alloy cast steel, with detachable lugs, and operated by Franklin power grate shakers. The ash pans are the Canadian National standard hopper type, the hinges being located so that the doors close of their own weight. It was feared, that on account of the flatness of the ash pan, due to the application of the Delta trailing truck frame in connection with the booster, that grates would be liable to burn out quickly, and in order to overcome this possibility, an auxiliary hopper was placed on each side of the ash pan, outside of the trailing truck frame. These auxiliary hoppers greatly facilitate the cleaning of the pan, and prevent the collection of cinders on the coping. The ash pans are also fitted with a sludge ejector, consisting of a 1¼-in. pipe from the delivery pipe of the inspirator to the ash pans, and a branch extending into each hopper, with valve operated from the cab. This arrangement is specially valuable, as it permits the direction of hot water into the pans to thaw them out, when the locomotives arrive at a terminal in freezing weather, with pans partly filled.



New Mikado or 2-8-2 Type Locomotive of the Canadian National Railways

The smoke stack is the Canadian National standard 3-piece type, the center piece forming the base and being fitted to the smoke box, extending down into it. The stack proper and the stack extension fit inside and butt together in the base extension, thus forming protection from the impinging action of the exhaust to the center piece, which constitutes the part that must be fitted to smoke box.

The rear end is fitted with a Commonwealth cast steel cradle casting. The driving wheels are 63 in. diameter with 56 in. centers, of cast steel. The main journals are 11 x 13 in. and others 10 x 12 in.

The crosshead is fitted with the Rogatchoff adjustment, which permits of adjustment of the shoes to take up wear. The trailing truck is of the Commonwealth constant wheels and 36 in. cast steel centers.

The steam distribution is provided for by Walschaert valve motion, controlled by power reverse gear, and all parts are interchangeable with those of previous Mikados. The diameter of the piston valves is 14 in. and the setting is as follows: Travel 6½ in.; lap 1 in.; lead ⅛ in.; exhaust clearance 0 in.

The cylinders follow Canadian National standard design, being equipped with the railway's standard by-pass valves, and four standard cylinder cocks to each cylinder, two being placed at the ends of the cylinder barrel in the usual manner, one placed at the center of the barrel and connected with a drain pipe from the bottom of steam chest, this pipe being covered by the cylinder jacket, and the fourth cock is piped to the exhaust cavities which are drained from each quarter. All eight cylinder cocks are operated in unison, by one set of levers. The cylinders are also equipped with the railways standard relief valve.

The cab is of the Canadian National standard short vestibule type, and has many interesting features. This type of cab makes it possible to have almost all the short stays in the sides of the fire box out clear of the cab, the few that remain inside being F. B. C. flexible type. The cab is securely riveted to the boiler, with a 3 x 4 in. angle iron around the whole front of the cab and on the boiler and in order to take care of expansion, the cab brackets are provided with a groove permitting the cab to slide on the cradle casting.

The cast steel turret, with eight outlets, has been placed outside, and far enough ahead of the cab to permit of grinding in, or packing, the operating valves, which are all of one standard design, entering the turret horizontally from the rear. The valve seats are at the front of the turret, six of the steam connections from the turret being fitted with a coupling nut and tail piece, tapped to suit the several pipe sizes, thereby permitting the use of one size standard operating valve. These operating valves are fitted with extension handles, carried into the cab and labelled. One feature about the valves is that none of them are threaded into the turret, each one being secured with a cast steel flange, and four studs tapped into the turret walls, bosses being provided inside of turret, so that studs do not go all the way through. This eliminates any leaky threads in turret, as well as simplifying removal of the valves when necessary. Not only has the turret been placed outside the cab, but also the inspirator, blower valve and stoker engine valve. This arrangement not only makes valves more accessible for packing, but removes the great danger of scalding in case of a sideswipe, or similar accident, that would tend to burst a steam pipe inside the cab. Wherever a valve such as the stoker throttle, feed water heater throttle, or blower valve, are outside of cab and under the jacket, a slide has been provided in the jacket directly over the different valves, so that they are easily accessible.

The sand box is fitted with Hanlon sanders; three World type safety valves are used, one muffled and two plain. The headlight equipment is made up of a Pyle-National Type K-2 turbo generator set, and Keystone type 1412 cage, fitted with a 14 in. Golden Glow reflector and C. M. S. focusing device, and Canadian National standard separate number lamp case, with sides oblique, this making for maximum safety in operation, by reason of the easier and more certain identification of locomotive numbers. The water level indication is secured by the Canadian National standard water column, welded directly to back head of boiler, and fitted with the road's standard try cocks and water glass fittings. The water glass is fitted with a special guard. The steam heat reducing valve is of the World-Leslie type, and the piston and valve rod packing is King metallic. The Franklin radial buffer and Unit safety bar are used between the locomotive and tender, and the piping between locomotive and tender is equipped with Barco joints. The engines are equipped with Shoemaker firedoors.

The tank is of the water bottom type of Canadian National standard design and construction, somewhat modified for the application of the Duplex mechanical stoker. The tank has a water capacity of 10,000 U. S. gallons and a coal capacity of 12 tons. The tender frame is of the Commonwealth cast steel type. The tender truck is the 4-wheel pedestal type, equipped with 34¼ in. wheels with semi-steel centers 28 in. diameter and 6 x 11 in. journals, all interchangeable with trucks on the previous Mikado type locomotives.

TABLE OF DIMENSIONS, WEIGHTS AND PROPORTIONS

Railroad	Canadian National
Type of locomotive	2-8-2
Service	Freight—Western region
Cylinders, diameter and stroke	27 in. by 30 in.
Valve gear, type	Walschaert
Valves, piston type, size	14 in.
Weights in working order:	
On drivers	227,600 lb.
On front truck	29,500 lb.
On trailing truck	57,700 lb.
Total engine	314,800 lb.
Tender	185,100 lb.
Wheel bases:	
Driving	16 ft. 6 in.
Total engine	35 ft. 9 in.
Total engine and tender	68 ft. 10 in.
Wheels, diameter outside tires:	
Driving	63 in.
Front truck	36 in.
Trailing truck	43 in.
Boiler:	
Type	Belpaire, Ext. wagon top
Steam pressure	185 lb.
Fuel, kind and B. t. u.	Bituminous coal
Diameter, first ring, inside	76 7/16 in.
Firebox, length and width	108⅛ in. by 84¼ in.
Arch tubes, number and diameter	4—3 in.
Cumbustion chamber, length	22½ in.
Tubes, number and diameter	240—2 in.
Flues, number and diameter	40—5⅜ in.
Length over tube sheets	18 ft. 0 in.
Grate area	63.26 sq. ft.
Heat surfaces:	
Firebox and comb. chamber	268 sq. ft.
Arch tubes	26 sq. ft.
Tubes	2,249 sq. ft.
Flues	1,008 sq. ft.
Total evaporative	3,551 sq. ft.
Superheating	885 sq. ft.
Comb. evaporative and superheating	4,436 sq. ft.
Tender:	
Style	Water bottom
Water capacity	8,300 Imp. gal.—10,000 U. S. gal.
Fuel capacity	12 tons
General data estimated:	
Rated tractive force, 85 per cent	54,600 lb.
Cylinder horsepower (Cole)	2,427 hp.
Boiler horsepower (Cole) (est.)	2,322 hp.
Weight proportions:	
Weight on drivers ÷ total weight engine, per cent	72.3
Weight on drivers ÷ tractive force	4.16
Total weight engine ÷ cylinder hp.	129.7
Total weight engine ÷ boiler hp.	135.5
Total weight engine ÷ comb. heat. surface	71.0
Boiler proportions:	
Boiler hp. ÷ cylinder hp., per cent	95.7
Comb. heat. surface ÷ cylinder hp.	1.83
Tractive force ÷ comb. heat. surface	12.31
Tractive force × dia. drivers ÷ comb. heat. surface	775
Cylinder hp. ÷ grate area	38.1

The Floating Bushing in the Side Rod

The heating of the main crankpin on large locomotives has been a source of annoyance for a number of years, and it was found that the side rod was the principal sinner in producing these results. In order to avoid this the floating bushing has been designed and put into service.

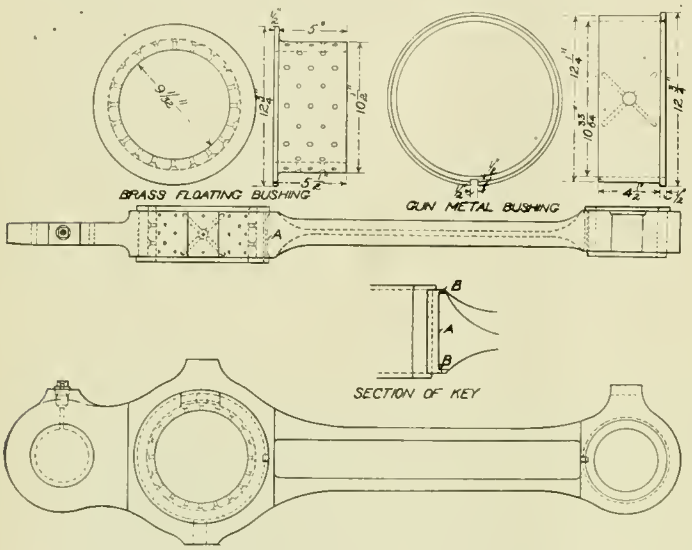
The bushing is, as its name indicates, floating, that is, loose in the rod, so that it may turn either on the pin or in the rod, with the result that it does both and thus divides the frictional reactions between its inner and outer surfaces. It is, therefore, an element in the lubrication of the pin, the frictional resistance developed, the lost motion, the cost of maintenance and the reliability of the complete unit for service.

The arrangement here shown is that used on the Chicago & North Western Ry., and was developed under the supervision of Mr. H. T. Bentley, the superintendent of motive power.

In order to protect the rod itself from the wear that would be caused by the turning of the brass bushing in it, a gun metal bushing is pressed into the rod, which thus affords the outer bearing surface for the inner bushing which is made of brass.

The two bushings are shown in detail and the dimensions are given for an application to the E or Pacific type of the road.

In addition to being pressed into the rod, the outer gun metal bushing is prevented from turning by the



Floating Siderod Bushing, Chicago & Northwestern Railway

key *A*. As will be seen from the detail engraving, this key is ½ in. square in the body and has a lip *B* at each end that is let into the rod, the ends of the key being flush with the sides of the same. The key is placed in position before the outer bushing is pressed into place and the lips prevents it from moving at all times.

The outer bushing has a flange at one end which, with the small surface of the inner brass, forms the bearing surface against the hub of the wheel.

The outside diameter of the outer gun metal bushing is 12¼ in., with an inside diameter of 10 33/64 in., while the outside diameter of the inside or floating bushing is 10½ in., thus allowing 1/64 in. clearance when new.

The diameter of the main crankpin next to the wheel center is 9 in. and the inside diameter of the brass bushing is 9 1/32 in. giving a play of 1/32 in. when new. From this it appears that the thickness of the walls of the outer bushing is 1/128 in. less than ⅞ in. while the thickness of the walls of the inner floating bushing is 47/64 in. This bushing is drilled with five rows of oil holes of ¼ in. diameter, with ten holes in each row, and each hole countersunk ⅛ in. deep on the outside to insure good lubrication. The holes in any two adjacent rows are alternately spaced. This inner bushing is slipped in from the outside of the rod and its flange forms the bearing surface against the side of the brass of the connecting rod.

In order to facilitate the flow of the grease to the outer surface of the inner bushing, the inside of the outer bushing is cut with two grooves, as shown. These are ¼ in. wide and ⅛ in. deep.

As already stated these bushings are in use on a number of railroads and are doing their work well and are an important element in the avoidance of hot crankpins. They do not pound out and when worn are easily and cheaply renewed. They are a departure, quite as important, from the solid, or keyed brass as the solid brass at the ends of the rods was from the keyed brass of the old locomotives, and are consequently of interest to those in touch with modern locomotive design.

German Railways Since the Armistice

In Germany, as in other countries, the building and operating of railways was left at first to individual enterprise and initiative, the State, as supreme power, conceding to private companies the construction and operating rights whenever such concessions were applied for. As a result, there was no comprehensive geographic or financial plan for systematic development and consolidation of the railways, and the evolution of such a plan was made difficult by the Empire's division into small States, each jealous of its sovereignty. When, therefore, on April 1, 1920, the several State railways were transferred to the Central Government (Reich Uerreichlichung), the long contemplated administrative and financial unit was formed for the first time in the history of German railways.

The Reich's purchase of the various railways and the individual State's cession to it of their right to purchase private companies resulted in the entire system of "general utility" railways being incorporated in the property of the Central Government, with the exception of local lines (suburban and street railways). The right of railway legislation is therefore vested in the Reich, under the constitution, and the Central Government, with the approval of the Reich Council, issues all ordinance regulating the construction, operation, and movement of its railways; the States issue no by-laws affecting the railways without the approval of the Reich Government.

Trackage, Rolling Stock and Employees

In 1913 the German state railways had a total trackage of 58,933 kilometers, divided as follows: Main lines, 34,730; secondary lines, 23,128; and narrow-gauge lines, 1,075. The Reich railways on March 31, 1921, had a total trackage of 53,222 kilometers, divided as follows: Main lines, 31,086; secondary lines, 21,074; and narrow-gauge lines, 1,062.

There were more locomotives, motor coaches, passenger and baggage cars, and freight vehicles available on the German railways at the end of 1921 than there were in 1913, in spite of the fact that nearly 7,400 German locomotives and 98,000 freight cars had been delivered to the Allies as a result of the treaty of Versailles. The following table shows the equipment available at the end of 1913, 1919, 1920 and 1921:

Serviceable rolling stock on German Reich railways at end of calendar year.

Class of equipment	1913	1919	1920	1921
Locomotive and railway motor cars	28,104	30,461	31,538	31,070
Passenger coaches	62,247	62,732	64,420	66,754
Baggage cars	17,037	16,409	17,207	20,741
Freight cars (including work-train cars)	655,139	640,489	659,371	700,577

During 1921 the average number employed per month on German railways was 1,050,888, a slight reduction from the 1920 monthly average of 1,089,840, but an increase over the 300,000 monthly average in 1913. It is said that the efficiency of the staff has been greatly reduced, not merely by the introduction of the 8-hour day but also by the food shortage and social unrest.

Practical Steps to Improve Our Transportation System*

By SAMUEL REA, *President*, Pennsylvania Railroad System

Our National transportation system is susceptible of great improvement. We are the most progressive Country in the World, and have the most efficient and cheapest transportation service, but it must keep pace with industrial growth if we are to retain our leadership in industry, agriculture, finance and commerce. Granting this, there are numerous steps which may be taken to achieve that result. If I were to attempt the answer in one sentence, I would say: "Give the railroads adequate net operating income by permitting them to earn, for a sustained period of time, at least a 6 per cent. return upon the property devoted to public service in the several districts or groups." Bring that about, and thenceforth there would be some foundation for an improved system of railroads in this country, and also a vastly better prospect for their future development and continued progress than has existed for more than decade and a half.

First and last the problem is one of railroad credit, which can have only one sound basis; that is the ability to earn a sufficient margin over all expenses and taxes—averaging the good years with the bad. It must be sufficient to attract capital investment on a large scale at reasonable cost, by assuring reasonable safety of principal, with the prospect of paying satisfactory income upon the capital used, and leave some margin of surplus to aid in sustaining credit or make improvements.

If the railroads earn a return of only 5 per cent. upon their property investment in such a year as 1923, with its record-breaking traffic how can they be expected to sustain their earning power in other years with lessened traffic? The answer is that they should be allowed to earn either a minimum of 6 per cent. in all years or else greater returns in years of general prosperity, in order to build up a surplus to tide them over the years of lighter traffic which are certain to come. It will be immediately asked, "What specific measures can be taken by which greater net operating income can be secured by the railroads?" As I view the matter, four possible methods suggest themselves:

1. Readjustment of the rate structure to yield larger revenues.
2. Lowering of labor costs.
3. Reduction in taxes.
4. Greater efficiency in operation.

As to the first suggestion, that affecting rates, there is no one in or out of the railroads bold enough to advocate horizontal advances, although the railroads are not earning a 6 per cent. return. The Committee of the Chamber of Commerce of the United States on "Readjustment of Relative Freight Rate Schedules," which considered this subject carefully, went so far as to recommend a general readjustment and revision of the structure of freight rates, having for its purpose a more equitable distribution of rates in accordance with the commercial ability of various classes of traffic to bear those charges. This process is a very necessary one to undertake. It is sound economically and commercially. It will have to be done sooner or later, but it will be unavoidably slow. Adjustments are going on all the time, but unfortunately most of them are downward. Meanwhile, some of the agricultural interests are demanding immediate reductions in their rates; and are insisting upon them regardless of consequences to the railroads, to other classes of shippers or to the Nation as a whole. Some years will be required to make a revision or readjustment of our entire rate structure, and while in the end we may expect from this work an improvement in railroad net earnings, together with relief to certain kinds of traffic now probably bearing more than its fair share of the burden, no beneficial results, either to the carriers or to shippers, can be expected in the immediate future. That does not mean that we should approach the work of revision in any faint-hearted manner, but tangible results will not be obtained for some time, and for the present we shall have to look elsewhere for practical methods to increase railroad net operating revenues.

We know that it is impossible to produce adequate transportation for the United States upon returns which for 1923 will only reach approximately 5 per cent., and that year was the greatest we have ever had, judged by the railroads' loaded car movements and the general prosperity of our people.

Therefore I sum up this first suggestion by pointing out that whatever may be the defects of the Transportation Act, and no matter how earnestly some people may advocate the revocation of the rate-making provision that rates must be made not to exceed a fair return, fixed at 5¾ per cent. (which is not a guarantee, but a restriction), the wisest course of all is to frankly admit that such provision has never been enforced since the Act was passed. Yet it was incorporated as one of the chief foundations for providing the American people with adequate transportation through increasing the net earnings and improving the credit of the railroads. We railroad men, business men and Commissions have not yet kept faith with the American people because we have never insisted upon the enforcement of that provision, which is vital to the whole Act and the health of the railroad service. Therefore, our present form of public regulation has not yet proven its ability to provide the railroads with a fair or adequate return.

Increasing Efficiency of Operation

Still another method suggested for increasing the net returns of the railroads is greater efficiency in operations. This must be considered under two subdivisions:

1. More efficient use of existing facilities.
2. Extensions of or additions to physical facilities, and the character which they should take.

These two questions, though related, are not identical, and I should like to consider them separately.

More efficient use of the existing physical facilities of the railroads involves many considerations. It will be understood that I have in mind such forms of enhanced efficiency as may be counted upon to produce improved net returns. Perhaps we shall have to take a more undisguisedly commercial view of the railroad enterprise than now generally prevails. The railroads are performing services in many directions which are not only unremunerative, in the sense of contributing nothing toward a return on the property, but in many cases result in actual out-of-pocket losses. Passenger trains are being kept in operation where, owing to changed conditions, the net receipts have fallen to extremely low figures or do not exist at all.

There are many branch lines on the Pennsylvania, and other roads throughout the country, which contribute nothing to the support of the systems as a whole, but are

*Abstract from an address before the Chamber of Commerce of the United States.

serious and increasing burdens. In other forms of enterprise, no less important to the social structure than the railroads, it is not expected that undertakings shall be indefinitely continued after changing circumstances have rendered them unremunerative. It is hard to see why a different criterion should be applied to the enterprise of railroading. We may well ask whether the test for justifying the continued operation of a particular service should not be its ability to pay its way, including the earning of taxes and of a fair proportionate contribution to the return on property investment.

I do not mean to imply that the necessity for railroad service is shrinking. Demands for transportation service in the last year have been the greatest ever known in peace times, and I have no doubt that even these high records will be surpassed in the next period of general business activity.

The railroads are, however, transportation machines which are becoming increasingly adapted to the rendering of service in bulk. We may regard them as the mass, or wholesale, carriers of the Nation. As their equipment, yards, terminals and other facilities become increasingly adapted to this purpose, they become less adapted to the retail forms of transportation—such as short-haul traffic and less-than-carload freight, and the shorter distance light passenger service.

These forms of service in some cases are a positive burden to the railroads. They are essentially the forms of service which motor vehicles or rapid transit lines can perform to the greatest advantage, owing to their greater flexibility of movement. We are, therefore, confronted with the question of the desirability of encouraging the further transfer to motor trucks and passenger motor vehicles of considerable portions of these kinds of traffic.

We have also to consider the advisability of the abandonment of totally unremunerative branch lines where public patronage has been transferred chiefly to motor cars, and the highways. It seems not unreasonable to say that, either in the case of freight or passengers, when patronage becomes too thinly spread by reason of being divided, the public should be called upon to say which kind of service is desired. Where there is a marked preponderance of choice in favor of the highways and motor vehicles, the railroads should be allowed discretion to abandon the field altogether, so as to concentrate their facilities in other directions, and thus serve a greater demand.

This subject is also intimately allied with the question of the revision of the rate structure. Permitting the railroads to raise rates on those forms of merchandise or other products which do not now pay their proper share, as measured by their value and the cost of handling, would permit a corresponding lowering of rates on certain primary commodities which are less able to bear the burden. It would also probably have the effect of giving further impetus to the shifting of high class, small lot short-haul merchandise traffic into the motor truck field.

This clearing away of unremunerative traffic, for which other and better adapted agencies are now available, instead of reducing the scope of railroad operations, would leave room for a vast increase. It would clear terminals for the long-distance traffic which the railroads can handle with incomparably greater efficiency than any form of motor vehicle, and which is certain of continued growth. It would prolong the life of existing terminals, and so help solve the extremely serious problem of providing more terminal room in our great cities, where realty values are becoming increasingly prohibitive. It would simplify railroad operation, and, by increasing the percentage of heavy tonnage movement, would also tend to increase materially the ton miles and passenger miles which a given working force would be capable of handling in a given period of time.

Although no definite program for meeting these problems is yet fully developed, they nevertheless deserve the most intelligent consideration by both the public and the railroad companies, and also by the interests engaged in manufacturing motor vehicles and all others concerned in commercial motor transportation.

The related question of increased or additional physical facilities, and the character which they should take to improve efficiency and to lay the foundations for cheapening the cost of transportation, brings us immediately back to that most fundamental of all railroad problems—the restoration and stabilizing of credit. Until that problem is assured of solution, no practical program for the sustained betterment or improvement of railroad facilities on any substantial scale, is capable of formulation.

From an engineering viewpoint there are many improvements which could be adopted, or the present use of which could be greatly extended, and which would very materially increase the efficiency and reduce the cost of railroad operation. The initial installations, however, would require the investment of very large sums of money, and it is difficult to see how these sums can be raised unless railroads are allowed to earn such fair returns that investors can be persuaded that they can receive at least as good a return, with as high a degree of security, as they know can be obtained in the industrial, mining, real estate, mercantile and other competing investment fields. Likewise, they should feel secure from punitive political attacks or legislation directed against the railroads.

Electrification of the railroads can be regarded as only in its infancy. Lack of funds has been the chief bar to progress for many years, and is today. Electrification promises great operating economies in many directions; and where adopted for built up territories, affords a great flexibility of service, such as tends to offset, to some extent at least, some of the difficulties in handling the short-haul and lighter forms of traffic to which I have just referred.

Experiments will continue with gasoline rail motor cars; grade crossing elimination must proceed; automatic signal crossing protection, and extension of block signals, and train control devices to enhance safety in general, must also be provided.

Without considering these demands for additional safety devices, or the requirements for maturing securities, this Chamber has estimated that railroads require about $787,000,000 per annum to meet the expected traffic growth.

I have now stated my general views upon four possible avenues of approach to a more satisfactorily sustained level of net earnings, having for its object the improvement of railroad credit as a basis for a sustained program of railroad progress.

It is interesting to see just where we stand in this matter of net operating revenue. In 1917, the year we entered the World War, the net operating revenue of all Class I railroads was $934,000,000. For the year 1923, based upon ten months' actual return, with the other two months estimated, it will probably be in the neighborhood of $970,000,000. In the meantime the huge sum of three and a quarter billions of dollars has been expended upon the railroads for additions to road and equipment. It will, therefore, be seen that the investment of that immense sum has brought practically no increase in net operating revenues, even in a year during which railroad traffic broke all previous records, and the general prosperity and spending power of the country were at the highest levels ever known.

That is not an encouraging situation upon which to base the raising of large sums of fresh capital for improvements. Nevertheless, still having faith in the fairness of the

American people, and their ultimate appreciation of an adequate transportation system, and relying upon a continuance of the underlying policy of the Transportation Act, to the effect that railroad investment will be protected, the railroads spent another billion in 1923, for more equipment and improvements, and have committed themselves to the expenditure of further large sums in the present year.

By these enormous expenditures, for which practically all of the capital has been borrowed on mortgages and other indebtedness, the railroads are attesting their belief in the future of the country. But, if we are to go much further, it is absolutely essential to get some tangible encouragement from the public and our governmental bodies indicative of their appreciation for, and their intention to properly support, an improved national transportation system. The railroads must not be made a football for partisan politics. Adequate net operating revenue is the one thing which will furnish the credit upon which such further sustained program of improvements must rest. It must be possible to show adequate net earnings not only in exceptional traffic years, such as 1923, but over a continued period. Without these factors there can be no permanent solution of the problem of railroad credit, which is at bottom the basic problem in improving our national transportation system.

Development of British Railway Groups

Consolidated Systems Attaining Post-War Efficiency Surpassing Pre-War Operations in Some Respects

The consolidated railroads of Great Britain are rapidly attaining a post-war height of efficiency that surpasses pre-war operations in many respects. The outstanding accomplishments of 1923 fall into the following categories: Further coördination of new groups; introduction of modernized equipment and revised operating schedules; expanded replacement programs for unemployment relief; reduction of charges; preparation of standard tariffs and revision of goods classification; adjustments of hours and service conditions of railway staffs; increases of traffic accompanying better trading year which require additional facilities.

By order of the Amalgamation Tribunal, the effective date of consolidation of the four railway groups was fixed at January 1, 1923. By the end of September the members found their task completed, so that the tribunal dissolved in October, 1923, leaving the new groups—London, Midland & Scottish, London & North-Eastern, Great Western, and Southern—controlling total route mileages of 7,790, 6,590, 3,800, and 2,200, respectively. This area arrangement has paved the way for many coöperative changes that are hardly apparent to the public except in improved service.

The rolling stock of all groups is in process of standardization, both as to color and design, and a small part already done stands to the credit of the first year of grouping.

Non-Stop Long-Distance Runs

Many innovations were introduced in twelve months of grouped running, and others are foreshadowed. Some of the non-stop long-distance runs are entirely new features. One is the North-Western journey from London (Euston) to Prestatyn, a distance of 205 miles. The North-Eastern has developed a Harrogate special from London which makes a 3-hour and 25-minute run to Leeds, the first stop, a distance of 185 miles. The Great Western established a speed record on its Swindon-to-London service, covering 77½ miles in 75 minutes, or an average speed of 61.8 miles an hour. Longer runs have been speeded up, as, for instance Paddington (London) to Aberystwyth, Wales, 234 miles, now advanced from a 7-hour to slightly under a 6-hour journey.

The modernization of rolling stock equipment covers a wide range. Larger and more powerful locomotives are being introduced. New passenger engines of the Great Western, the most powerful used in Great Britain, have a tractive force of 31,625 pounds, compared with previous four-cylinder types of 27,800 pounds. The North-Eastern lines have installed higher-powered freight locomotives for the coal, steel and other heavy traffic of east coast industrial areas served by that system.

The Great Western Railway has been pioneering steadily during 1923 for larger freight cars and offers 5 per cent freight rebates to private owners for the adoption of 20-ton coal wagons. The Great Western also intends to adopt Pullman vestibules, articulated carriages, electrical cooking and lighting, steam heat, automatic couplings, and to experiment on bufferless short-coupling trains, an entirely original departure for English lines.

Reduced Charges

The year opened with a cut in all passenger fares to 50 per cent above the 1914 levels from the existing 75 per cent. Freight tariffs underwent a sweeping reduction about August 1 to a general average of 50 per cent over pre-war on merchandise traffic. Dock charges at railway-controlled ports, such as the Great Western chain along the Bristol Channel, or at the railway-owned facilities of the North-Eastern in North Sea ports, have also become less burdensome to traders during the year. The railway groups have gone so far in these several concessions that there is little immediate prospect for further reductions.

The Railway Rates Tribunal set up by the Railway Act, 1921, was entrusted with the preparation of a revised commodity classification and the adoption of an agreed schedule of standard charges. The first has appeared in published form and the second is in process of publication. The classification will include 21 separate numbered classes of merchandise instead of 8 at present used, some of the exceptional items in current tariffs having been made distinct classes. Its actual adoption now awaits the selection of the "appointed day" on which the proposed standard charges, when agreed, will come into effect in conjunction with the classification. Because of inherent difficulties, as much as two years may elapse before the prescribed rate bases can come into use.

Satisfactory smoothness has been continued in the adjustment of railway labor matters during 1923. Wages have altered but slightly downward with the cost of living decline, until the mid-year. Since then a steady recovery of the index to 77 per cent in November will mean that workers entitled to a bonus on the standard wage will receive an increase of one shilling weekly from January 1, 1924.

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The Land Grant—and the Facts

Sixty years ago when much of the Northwest was a wilderness, the Government, by Act of Congress, made a grant of land to a group of individuals on condition that they would build a railroad to the Pacific Coast over the Northern route.

This grant became the Northern Pacific Railroad land grant. It was not a "gift" as many persons believe but was really a bonus paid for the completion of a difficult and immensely expensive undertaking—an accomplishment which the Government much desired but was unwilling to attempt.

Lack of transportation facilities and hostile Indians made land in the Northwest inaccessible, and although it was being offered for sale by the Government at $1.25 an acre there was no demand for it.

Only the odd numbered sections within 20 miles of the railroad within the States and 40 miles within the territories, non-mineral, and not excepted because of Indian and military reservation or because of entries under land settlement laws, were granted to the company, but the Act automatically raised the price of all even numbered sections within the limits of the grant to $2.50 per acre. Thus the Government, by encouraging the construction of the railroad, not only created a good market for its remaining land, but fixed a price calculated to reimburse it for the land grant.

Thousands of acres of the land grant have been sold by the company for from 25 cents to $1.50 per acre. Even with the higher land prices of recent years, the net receipts average only $3.09 per acre for all land sold up until June 30, 1923.

From any point of view, the land grant could not be regarded as a "gift." Railroads which received land grants are compelled by law to carry the Government mails at a discount of 20 per cent from the regular compensation and this discount had cost the Northern Pacific $4,968,597.79 up to June 30, 1923. Another laws compels these railroads to carry Government freight and passengers such as troops, military supplies, etc., for half of the usual rate. Here again this reduction had cost the Northern Pacific $8,846,330.67 up to June 30, 1923. These reductions will continue to be made, subject to the control of Congress, as long as the road is operated.

The company has fulfilled the conditions of the grant. Before there was enough business to pay operating expenses, it built the railroad which was necessary to start the development of the great Northwest.

Yet it has paid and continues to pay in actual dollars for every acre granted to it by the Government. No subject has been more misunderstood by the public. In the long view, the Northern Pacific would have been better off had it purchased the land from the Government outright, instead of accepting a land grant with the attendant provisions and obligations, but this was not apparent at the time and it was easier to raise money for the building of the railroad with this inducement to investors.

Investigation of Power Brakes and Appliances

During the past few years several tests have been made of a new type of triple valve on different roads that have had the equipment in service to determine its merits, if any, when compared with the present standard brakes of the railways of the United States.

All of these tests have been on lines handling heavy coal traffic and on one, the gradient is the heaviest of any main line steam road in this country.

Hearings have been held by the I. C. C. at Washington on this matter at different times and a vast amount of evidence has been taken, some of it valuable, but much of it secured at great expense serves no purpose whatsoever.

As a result of complaint filed with the Commission as to efficiency or safety of power brakes, certain railway executives were summoned to appear before the Commission in Washington on February 25, and explain what, if any, steps they had taken or had under way to test out new devices or otherwise improve the safe handling of trains and thereby insure a higher degree of safety to life and property.

These executives appeared and testified definitely, clearly, and in considerable detail to the effect that:

(a) Their present standard power brakes were both efficient and satisfactory.

(b) That they were at all times receptive to determine by actual use or other form of test the merits of new inventions and devices, particularly those wherein safety of life or property might be given a greater degree of protection, but that they knew of no new design of brake, or attachment to their present standard brakes that would give this result, and they did not feel disposed to substitute devices of undemonstrated merit for those of proven reliability, particularly where the hazard was so great.

The position of the railways, as reflected by the foregoing, seems to be well borne out by the facts developed in operation. A few of the more salient points will best serve to illustrate this feature.

In one year our railways handle more than one billion passengers, amounting to approximately 40,-000,000,000 billion passenger miles. During the same period there is produced about 370 to 400,000,000,000 freight ton miles, a most phenomenal record in transportation that would be impossible without reliable, efficient power brakes.

Practical Tests of Power Brakes

There are handled on our railways each year about 15,000,000 trains.

Fifteen million trains per year means about 41,093 trains per day, and assuming the power brakes are used only 30 times in the control or handling of these trains (which is extremely low) we then find on calculation the following results: 41,093 trains per day x 30 or 1,232,790 practical demonstrations in each 24 hours, and 51,366 each hour of the day, 856 per minute, and for each time the clock ticks more than 14 practical service tests of air brakes.

More than 19,000,000 people in the United States, or about 53,000 to 54,000, go to bed each night in sleeping cars, and are hauled through the country at varying speeds of from 20 to 75 or even 80 miles per hour, placing their lives in the hands of the ever watchful man at the throttle, who with the power brake is ever ready to avert impending danger, but without which the present volume of business would be an absolute impossibility.

With the wonderful development of our railways, particularly in the matter of ultra modern equipment, and its integral parts, it is not surprising that our foreign railway friends seek to adopt for use on their equipment devices that have proven so highly satisfactory on our railways as is evidenced by the action of two commissions whose decisions were reported in Railway and Locomotive Engineering of September, 1923, and January, 1924.

France Adopts the Westinghouse Brake

The Superior Council of Railways of France has ratified the decision of a special commission appointed by the Ministry of Public Works adopting the Westinghouse air brake as the standard for French railways. The special commission tested three brakes, viz., the Westinghouse, the Lipkowski and the Clayton-Hardy vacuum. It is now proposed that the French Minister of Foreign Affairs should call a meeting of representatives of the allied countries in accordance with the Peace Treaty with the view of standardizing air brakes in Continental Europe. The choice of the Westinghouse brake is said not to involve its exclusive use, but that any other similar pressure brake, capable of being operated with the Westinghouse, might be allowed.

Westinghouse Brake Adopted for European Railways

An international commission, composed of representatives of France, Belgium, Great Britain, Greece, Rumania, Yogoslavia and Czechoslovakia, has adopted the Westinghouse triple "L" valve brake as the standard continuous brake system to be used in European countries. This action was in accordance with Article 370 of the Treaty of Versailles, by which Germany undertook to introduce on freight trains a continuous brake of a type which might be adopted by the victorious powers within 10 years following the adoption of the treaty.

The delegate from Yogoslavia, inventor of a system of brakes widely used in that country, opposed the adoption of a uniform brake system. He was supported by the Czecho-Slovak delegate, who claimed that the changes required in his country would cost 400,000,000 francs, an expenditure which his country was unwilling to undertake.

The Westinghouse brake stood extensive and exhaustive tests by the French commission appointed to consider the type of brake most suitable for use on French cars, and received the commission's unanimous approval. As a result, this system has been adopted by the international commission, with the proviso that the countries involved are free to adopt any brake which can be used contemporaneously with the Westinghouse brake. It is maintained that the use of a variety of brakes as agreed upon is an improvement over existing conditions, but that the several systems will be more expensive to maintain than a single system.

From the foregoing it would seem to be safe to assume that by an overwhelming majority of the best minds competent to pass on this most important question, the standard brakes now in use on our railways are not only efficient and safe, but that those who have charged them with being unsafe, inefficient and inadequate find their complaint without support.

Elsewhere in this isue will be found the testimony of one of the leading railway executives of this country, Mr. Julius Kruttschnitt, who is eminently well qualified to speak on all phases of railway construction and operation.

Mr. Kruttschnitt's clear cut, definite statements, void of ambiguity should leave no doubt in the unbiased mind as to the character of equipment on the Southern Pacific, and the high standard of efficiency obtained in its operation.

What Is a Progressive?

There is a surprisingly small number of our citizens who either understand or can give a clear practical answer to the above question.

In political circles it may be safely said that most of those who are shouting their own self-estimated virtues from the house tops, and denounce about all others as reactionaries, are in the last analysis only cheap, half-baked political squirts, and if relegated to obscurity, where they belong, the country would be better off.

In the railway field, this pseudo-modern Sir Galahad who sallies forth to honor the righteous and punish the wicked, passing judgment on all manner of men and things, not infrequently exhausts the patience of those who are accustomed to severest trials in the various phases of their activities.

Baiting the Railways

One of the favorite indoor sports is to attack the railways in season and out, accuse them, personally try them, and find them guilty of all crimes in the category, and then call on public sentiment and if possible through legislative action to enforce their star chamber Bolshevik decree.

A charge that appeals to the public mind is that the railways have always and are now absolutely opposed to any and all improvements, particularly those that have to do with safety. While the writer holds no brief for either side of this controversy and will admit that in the railway official field, as in that of materia medica, theology or law there are a few weak sisters or scamps who ought to be engaged in something else, yet the charge when and as unusually applied to the railways as a whole is an absolute falsehood and will justify the use of the short and ugly word.

Automatic Vertical Plane Couplers

In the late eighties and early nineties there was much agitation on the question of adoption of an automatic coupler in place of the link and pin then in use and this controversy raged until compliance with the law about

1900. One of the fundamental features of this and all other similar controversies that the public does not understand, and which every promoter whose wares have not been adopted does not intend they shall understand, is the plain cold fact that the railway officer who "stands four square" against the use of material or devices of unproven merit is generally the one most vigorously assailed.

In 1898 and 1899 many railways were ready and had for some time been receptive to the complete equipment of all revenue freight cars, where it was physically possible, with automatic couplers, but of some 30 or 40 in use many were simply impossible freaks and their use was far more dangerous than the link and pin. Yet, the men who stood their ground, refusing to squander the corporate funds of the companies they served on undeveloped devices, were denounced as reactionary and as opposed to progress or improvement. As proof of the foregoing, not a single one of the numerous unreliable freak couplers which it was sought to force on the railway by public opinion or process of law could be found anywhere a few short years later except in the scrap pile.

The same was true with respect to several other problems, most all of which would have been properly solved much sooner and with a much greater degree of protection to the public and to the shareholder if there had been less interference and meddling on the part of politicians and promoters who are as a rule actuated by motives other than protecting the dear public.

"Transportation Waste" Has Been Cut in Half Since 1920

"Transportation waste" has been more than cut in half since 1920, the last year of Federal control. Transportation waste includes the cost of injuries to persons, clearing wrecks, damage to property, damage to live stock on right of way, and loss and damage to freight and baggage.

These facts are brought out in a report entitled "The National Cost of Railroad Accidents," recently published by the Equitable Life Assurance Society of the United States.

Transportation waste increased from $65,607,043 in 1916, or 1.82 per cent of the total operating revenues of the Class I railroads in that year to $85,745,052, or 2.14 per cent of the operating revenues in 1917.

Year	Total Railway Operating Revenue	Total Waste	Ratio of "Waste" to Total Revenue
1916	$3,596,865,766	65,607,043	1.82
1917	4,014,142,747	85,745,052	2.14
1918	4,880,202,255	113,493,816	2.33
1919	5,144,466,361	167,830,504	3.26
1920	6,178,192,428	216,057,347	3.50
1921	5,516,556,455	134,267,730	2.43
1922	5,559,092,708	91,009,479	1.63

By 1919 transportation waste had increased to $167,830,504, or 3.26 per cent of the operating revenues. And in 1920 this item was $216,057,347, or 3.50 per cent of the operating revenues.

In 1921, the first complete year under renewed private operation, transportation waste had been reduced to $134,267,730, or 2.43 per cent of operating revenues. In 1922 it was reduced to $91,009,479, or 1.63 per cent of the operating revenues. Thus the 1922 ratio of "waste" to operating revenues was less than half of that of 1920.

The above figures are from the report of Lew R. Palmer, conservation engineer of the Equitable Life Assurance Society of the United States.

The Pension System of the Pennsylvania

Retired employes of the Pennsylvania Railroad System received a total of $3,698,636 in pensions during 1923. This is shown in reports of last year's work and activities of the Pension Department which are now being compiled by Superintendent E. B. Hunt. The pension payments in 1923 exceeded those of the previous year by $383,972. During the twelve months there was a net increase of 1,083 in the names of workers who have been relieved of their active duties and placed upon the "Roll of Honor" under the pension regulations.

The pension plan of the Pennsylvania Railroad System was inaugurated January 1, 1900. In the twenty-years which elapsed between that date and December 31, last, the company paid out a total of $32,187,868 in pension allowances, and retired under the plan a total of 16,406 employes. Of these 7,376 are now living and receiving pensions.

There are at present thirty-one retired workers on the "Roll of Honor" who are ninety years or more old. Their combined ages total 2,845 years. There are 772 pensioners who are eighty years old or over. Of the ninety year men, eight have been on the "Roll of Honor" for more than twenty-three years each, having been among those retired when the pension plan was originally established.

An analysis of the service records of the entire group of "Roll of Honor" men shows that the typical Pennsylvania Railroad employe renders about forty years of active service prior to retirement.

The regulations of the company's pension plan apply impartially to all officers and employes, regardless of rank, grade or position. Every man or woman in the service, upon reaching the age of seventy years, is automatically retired. Between the ages of sixty-five and sixty-nine, inclusive, workers who are physically or mentally disqualified for active duty who have rendered thirty or more years of service may be placed on the "Roll of Honor" upon special recommendation.

The pensions are all calculated upon a uniform basis. One per cent of the average earnings for the last ten years of active work is allowed for each year of service. Thus, a man or woman who works fifty years, practically devoting his entire active life to the company's duties, receives substantially half pay.

These pension allowances are paid entirely out of the company's funds, as voluntary gifts in recognition of long and faithful service. In addition, all employes who desire to do so are now afforded an opportunity to increase their pensions by becoming members of the Employes' Provident and Loan Association, and contributing specified amounts from their monthly salaries which sums are invested and form the basis for increased income upon reaching the age of retirement.

Canadian National to Study Diesel Locomotives

The Canadian National Rys. has sent to Europe three engineers who will investigate certain lines of engineering development, including the use of Diesel engine powered locomotives on Swedish railways. The engineers detailed on this interesting mission are Messrs. C. E. Brooks, chief of motive power, Canadian National system, Montreal; E. W. Oliver, general superintendent, Niagara St. Catharines & Toronto Ry., Toronto, and R. J. Needham, mechanical and electrical engineer, central region, Toronto.

The Pennsylvania Railroad and the Modern Locomotive

How the Start was Made for a Great Increase in the Power of Locomotives

By GEO. L. FOWLER

In the February issue of this paper there was a brief account of the designing and operation of locomotives on the Pennsylvania Railroad of fifty years ago. Such an account would not be complete were it not to be supplemented by an account of the part played by the mechanical department of the railroad in starting the locomotive on the way to its present development in size and power.

In the late seventies of the last century the ordinary locomotive used for burning bituminous coal had its firebox located between the frames and between the axles of two of the driving wheels. As these frames were between the driving wheels and the driving wheels could not well be spaced more than nine inches from center to center, because of the danger of breakage of the coupling rods, the actual dimensions of the grate, when all allowances were made for the width of the water leg of the firebox and the necessary clearance of the eccentrics and axle boxes, were not much more than three feet wide and six feet long. This was capable of burning coal in sufficient quantities to get good work out of a heating surface of about twelve hundred and fifty square feet which could supply steam for a cylinder of from sixteen to seventeen inches in diameter, having a piston stroke of twenty-four inches.

It was accepted and stated that the locomotive having attained these dimensions had reached the limit of its power and size. The opinion was held, not only by the ordinary railroad officials and laymen but I heard it once promulgated as a fact by three of the, at the time, best known locomotive men in the country. It will be seen from this, that the problem of increasing the size and capacity of the individual locomotive was regarded as a most formidable one.

Attention has already been called, in the columns of this paper, that, at that time, there were very few, if any, technically trained men at the head of the mechanical department of American railways or engaged in the work of designing and building locomotives. The result was, that nearly all work of this kind was based on precedent, and what precedent did not sanction the designer did not attempt.

It was here that the technical training of Mr. Theodore N. Ely, who was, at the time, superintendent of motive power of the Pennsylvania Railroad, stood him in good stead and enabled him to take a step unprecedented for its boldness, and which the cold calculations of his mathematics enabled him to take with the confidence of success.

We have seen that the size of the grate was the limiting factor in the size of the locomotive, that is of the boiler, for it would be useless to have big cylinders unless the proper amount of steam could be provided for their consumption. The grate was limited in size by its position, and it would be useless to increase the dimensions of the heating surface unless sufficient coal could be burned on the grate to make a proper use of it. The whole question, therefore, hinged on what could be done to increase the grate area. It was solved by Mr. Ely, in what seems to us now as the simplest way in the world, but which at the time, raised a cry of protest if not of horror from almost every one, who knew of what he proposed to do.

His solution was simply to lift the boiler into air and widen the fire box so that it would rest on the top of the frames instead of being between them. This would make it possible to add eight inches to the width of the grate while, it now being well above the axles, it could be extended so as to reach over them and thus be limited in length only by the capacity of the fireman to properly throw and place the coal upon the fire.

The protest came from all sides that such an elevation of the boiler would so raise the center of gravity of the machine that it would be unstable on curves and that its centrifugal force would overturn it.

Before building such a locomotive, the weight of every part was carefully calculated, the center of gravity of the whole, determined and its position on curves at high speeds ascertained, all of which showed it to be stable. And this was about the first investigation that had ever been made as to the stability of locomotives. And so the engine was built as a result thereof.

Still in deference to public sentiment, on the first trial run from Altoona to Harrisburg, the speed was limited to forty miles an hour. But so steadily did the machine run, and so smoothly did it negotiate the many curves on the line, that orders were given for a high speed return, and this was done at a speed of about sixty miles an hour.

The demonstration was a success, the heating surface even in this first experimental locomotive was raised to between seventeen hundred and eighteen hundred square feet, and the class K locomotive as it was known, introduced a new era into locomotive construction.

It showed the way to great advances in power, a way that was followed by designers all over the country until today, the low boiler and narrow firebox is a thing of the almost forgotten past so completely has it disappeared from the practice of the country. The high boiler is now a matter of course, its stability and easy motion is recognized, but at the start it required a courage of conviction, and a certainty of position and success to do that simple little thing of raising the center of gravity of the boiler so that there might be room above the frames for the construction of a grate of sufficient dimensions to meet the growing demands of the traffic of the time at which it was done. It was but another exemplification of the ease with which an egg can be made to stand on end if you have some one to show you how to do it. And this was in 1881.

The ten years following the construction of the class K locomotive were years of exceedingly rapid progress in the growth of the machine. In this first engine the increase in heating surface had been of great moment but had not risen to the limit of the possibilities. Still when once the principle of the high center of gravity was established as correct, the number of square feet in the heating surface was increased by leaps and bounds until it was up to between 2,800 and 3,000 square feet with a corresponding increase in cylinder capacities in a very short time.

This increase in the size of the boiler was accompanied, in 1889, by a modification in form which was later made the standard of the road. This was the introduction of the Belpaire firebox, in which connected stayed surfaces are parallel to each other and the staybolts are at right angles to these surfaces.

In this there was a characteristic action. A critical examination of the firebox had convinced Mr. Ely that the principle on which it was constructed was correct. So when the first was put into service and it developed weaknesses and a tendency to leak, instead of abandoning the design as inferior to the radial stay boiler which, after years of experience, could be made tight, he proceeded to ascertain the stresses that caused the leakages, and then introduced such modifications in design that these stresses would be relieved, after which the trouble ceased, and he was warranted in having the Belpaire form adopted as the standard of practice of the road.

Prior to this, in 1887, attention having been directed to the use of oil as fuel on some of the Russian railways, experiments were made on the Pennsylvania to determine the feasibility of its adoption by that company. From a mechanical and operating standpoint the results of these experiments were satisfactory and proved it to be quite possible to use oil in the firebox of the Pennsylvania locomotives. But, when it was considered that the daily coal consumption of the road was then about eight thousand tons it was at once seen that the equivalent oil consumption would be about one-third of the total supply of the country, so that were this to be adopted by one road, the price would immediately rise to a point that would make its use commercially impossible. Mr. Ely, therefore, recommended that the matter be dropped and the experiments were discontinued in consequence.

It was during this period, too, that the railroads and manufacturers began to look into the merits of the compound locomotive. Under the spur of the representations of the builders, a number of railroads encumbered themselves with various types of compounds that did not prove to be economical in the long run and have since been abandoned. The policy of the Pennsylvania to thoroughly investigate a new device and make it earn its spurs before adopting it was followed with exacting rigor in this case.

The very favorable reports that had been received from abroad, as to the economical performance of the compound locomotive, especially on the State Railways of Hanover, under the guidance of Herr August von Borries and of the London & Northwestern Ry. of England, where Mr. F. W. Webb was mechanical superintendent, were of such a character that no progressive superintendent of motive power could afford to ignore them. Accordingly in 1887, an order was placed for the construction of a Webb three-cylinder compound locomotive. It was built, brought to the United States and placed in service between Philadelphia and Altoona and also between Philadelphia and Jersey City. The engine was given every opportunity to show as to what it could do, but the net result was a most emphatic demonstration that it was not suited to, and could not meet the requirements of American service. It failed entirely because it was not suited to the work, and not because of faulty design or workmanship. Its workmanship was excellent in every respect, but so expensive was it in coal consumption and maintenance that it would have been more profitable for the company to have thrown it upon the scrap heap immediately after its receipt, than to have attempted to use it. It was, however, run until its inadaptability to the road was proven, beyond all peradventure when it was sent to the different shops so that all of the men could see it, and was then dismantled.

Again, in 1892, to further test the compound locomotive, examples of this class were purchased from the Baldwin Locomotive Works, and Schenectady Locomotive Works, and one of the two-cylinder class was also built on the Linder system from original designs at Altoona. But, after the crucial trials and scrutiny to which they were subjected it was decided that none of them were possessed of sufficient merit to warrant their adoption, so that from that time on the designs were confined to simple engines.

Later, however, in 1904, a De Glehn compound locomotive was imported from France, and again there was a failure to meet requirements, though the finish and workmanship on the engine was elegant in the extreme.

Meanwhile, during the whole period from 1888 to 1889 Mr. Ely was carefully watching the work and the road was experimenting with compound locomotives, for in 1892 he expressed the opinion that in the system lay the probable reduction in the cost of locomotive operation. But despite their tests or possibly because of them, none of the reports received convinced Mr. Ely or his advisers that it would be an economical success under the exceedingly varying and trying conditions to which it must be subjected on the Pennsylvania Railroad.

At the same time there were a number of roads that were equipping themselves very completely with compound locomotives and were reporting most favorable results in coal saving and general maintenance expenses. It naturally followed that the attitude of Mr. Ely and his road, was subjected to very severe and adverse criticism, mainly on the ground of being non-progressive and too conservative. Whereas the facts were that the compound locomotive would have been only too eagerly adopted, had Mr. Ely and his associates been able to convince themselves that the machine was of value. They had made their investigations before adopting while other roads had been content to take the representations of the manufacturers, who, while undoubtedly perfectly honest and sincere in all that they said, had not carried on tests of sufficient length and thoroughness to really know.

But the compound locomotive, as introduced in this country was a competitive enterprise. Each manufacturer had his own design to exploit and used it as a means of making sales. But immediately upon the consolidation of a number of the builders, the compound locomotive exploitation ceased, and they gradually went out of existance except in special cases, thus finally corroborating, by practice, the position that has been assumed on the Pennsylvania.

At times the pressure to adopt the compound locomotive was very great and a single case in point will serve to illustrate the situation. Mr. F. D. Casanave was superintendent of motive power at Altoona during the controversy and was offered, and accepted the position of superintendent of motive power of the Baltimore & Ohio. A few weeks before he left the Pennsylvania he sent some members of his staff to the Baltimore & Ohio to inquire into the service rendered by the compound locomotives, because of the pressure that was being brought to bear to purchase some for the Pennsylvania. They came back with very favorable reports. They had not witnessed any performance themselves, but talked with the men who were handling them, and it looked as though the Altoona officials were holding back too firmly. But Mr. Casanave had not been on the Baltimore & Ohio a week before he telegraphed Mr. Ely not to take any action on the report of those men, until he (Mr. Ely) should hear from him (Mr. Casanave). He said that they had come away with a very wrong impression, and it shows how difficult it is to go to any road that is not investigating a thing critically and get information on which action can be taken with reliance. And Mr. Ely's position, to the end, was that he had never been convinced as the result of any investigation that the compound locomotive is practical and economical for American practice. It will save some coal, but if it is charged with time lost, additional cost of repairs and interest on first cost, the balance will be on the wrong side of the account. And this position is not taken because of the failure of the Pennsylvania Railroad to use the compound locomotive, because at the outset, the theoretical advantages of compounding appealed to him very strongly and he was enthusiastic in the anticipation of its possibilities that never materialzed.

In probably no other issue connected with locomotive development did Mr. Ely exhibit his peculiar mental characteristics more than in his attitude toward the compound. Disposed to enthusiastically endorse its application from theoretical considerations, he laid aside all personal inclinations and allowed his judicial instincts to control, made investigations to determine the facts and when these facts were determined he stood by them regardless of all other influences, to have his judgment upheld, in the end. by the common practice of other roads of the country.

Up to 1893, the date at which Mr. Ely was appointed Chief of Motive Power, the heaviest locomotive built by the road was a consolidation, the HSsb, weighing empty 223,000 lbs., of which 194,000 lbs. were upon the driving wheels. This engine had cylinders 24 inches in diameter with a piston stroke of 28 in. For passenger service the heaviest locomotive was a Pacific (K2-9s) type weighing 280,600 lbs. empty, of which 161,400 lbs. was upon the driving wheels, or 26,900 lbs. on each wheel. To compare this with the weight of about 81,000 lbs. for freight and passenger in 1874, vividly presents the locomotive development that had taken place during the administrative life of a single official.

Closely affiliated with the development of the motive power of the line, though quite distinct from that of the steam locomotive, is that of the electric motor. In this, Mr. Ely was an experimenter and investigator, not a promotor or designer. It was in 1889 that the Pennsylvania Railroad became interested in electricity as a means of transportation. The first action taken was the equipment of the Atlantic City street cars with electric motors, and so unprepared were the electric companies of that date to furnish equipment, that it was necessary to wait a month before the old Edison Company at Schenectady could develope a motor which they were willing to deliver. This was long before Mr. Westinghouse had anything to do with the subject. And even when they did come, the trucks that were delivered with the motors were about as badly designed as anything mechanical could be. They had been made by an electrician, not by a railroad men, and one who knew but little of mechanics.

Then came the agitation for the construction of a new and electric line from Camden to Atlantic City by interests opposed to those of the Pennsylvania Railroad. This led to active work on the part of the railroad and Mr. Ely and his associates were instructed to investigate and see what could be done. It was for that reason that the experimental line between Mt. Holly and Burlington, New Jersey, was equipped for electric traction, the work being done by the Westinghouse Company. One object was to ascertain the speeds that could be obtained and similar data. That was in 1895, and coincident with, or a few months prior to the opening of the first line by the New York, New Haven & Hartford Railroad at Nantasket Beach. The first printed schedule of electric train operation, was, however, probably issued by the Pennsylvania.

The traffic was very light between Mt. Holly and Burlington and there was really nothing into which it could be developed. So, after operating it for a few years, it was abandoned. It was really purely an experimental line. Even the air brake that was used on the cars had to be developed for them and it was necessary to wait for months for its delivery.

Then the outside development of electric traction went on with leaps and bounds to return to the Pennsylvania in the electrification of the line to Atlantic City and of the great terminal in New York City.

Aside from the question directly connected with the locomotive and its development as a machine of greatly increased unit capacity, there were innumerable questions of detail constantly arising and upon which decisions had to be rendered by the mechanical department of the railroad.

These involved not only the form of the details but the materials of which they were made. The quality of the steel and iron to be used; the character of the boiler lagging, the introduction and use of steel castings, the various attachments and cab fixtures that go to make up the complete locomotive, all of which the superintendent of motive power is responsible for and upon which he must pass before they can be used.

In all of this work, the same judgment was exercised that had been put into more weighty affairs, with the result that the stamp of the simplicity and beauty of design of the Pennsylvania locomotive has left its imprint on the work of all American designers.

Snap Shots—By the Wanderer

The railroad was in the market for something. It may have been locomotives. It may have been cars. It may have been shop tools. All that is neither here nor there, nor your business nor mine.

Two firms were bidding for a specialty. Both were financially substantial. One was an old timer at that specialty. Had been in at its birth as it were. Had nursed it through all the weaknesses of babyhood and seen it developed into a strong and vigorous manhood. It was a firm who knew the game from the ground up. It knew all that was required in the way of metal and workmanship in order to get results and it was faithfully using all of its knowledge for the benefit of its customers and its own reputation.

When all this had been accomplished and the market had been established, firm No. 2 seeing a fine chance to share in the harvest of a good thing started in as a competitor. Position and influence and money gave them a good start, but somehow they did not quite have the "know how." Their goods looked exactly like those of No. 1, but in wear and tear and service they did not stand the racket as well. There was something lacking. Something the customers could not quite tell what. But something.

The story goes that when Beau Brummel was at the height of his career as the leading dandy of London he mortally offended the Prince of Wales, who essayed something in the dandy line himself, by inquiring of a mutual acquaintance in quite audible tones: "And who is your fat friend?"

From which time on there was a sartorial war to the knife between the two.

Brummel appeared in cravats of marvelous delicacy of texture and fluffiness, the admiration and envy of all of London's clubdom. The Prince strove in vain to copy, to learn the secret, but to no avail. His neckwear was as nothing to that of Brummel's.

Then came the fall and Brummel in disgrace and poverty sent one laconic note to his former rival: "Starch is the man."

It probably is not starch, but it may be something equally insignificant that marks the difference between the products of No. 1 and No. 2. At any rate it is there.

Realizing that something was wrong, No. 2 tried various means of getting trade. It cut the price. It offered No. 1 to stay out of certain territory and give it, oh, ever so big a percentage of all of the business of the country, if they would raise prices. But, no. No. 1 went externally, serenely, but inwardly angrily on its way.

Now, when the officials who had the decision to make on those locomotives or cars or shop tools, we don't know which, came to the final vote on the matter, it was a case of low price against high "know how." And as they were responsible for maintenance and all the little elements of what we call safety, they voted for the "know how."

There is an ethical side to this true story that the business-is-business man usually overlooks. Aside from patent rights, it has always seemed to me that the "laborer is worthy of his hire." And that a concern who has developed something out of nothing, that is, made a market for an article that did not exist before they created it, is entitled to a free field and no competition, so long as they do not abuse their monopoly. And that others who force themselves into a market in which they took no part in the making, are—well in the animal world they are called jackals. This may be poor business, but surely it has some ethical merit.

But, after all, isn't a manufacturer's "know how," or conscience worth paying for? That is really what you do when you engage a doctor or lawyer or engineer or anyone for a responsible position. Little Buttercup sang many years ago:

"Things are not always what they seem.
Skimmed milk masquerades as cream."

Certainly nothing can be truer than that in the machinery and tool line. It is so easy to put on a finish that looks "just as good," but isn't. Bearings whose workmanship has been scamped have a way of running hot, and machine tools that are not most carefully made cannot be relied upon to turn out good work. Yet I have seen German imitations of high grade American tools impossible to distinguish from the originals by merely looking at them. It was a case of skimmed milk and cream again.

There is this to be said in favor of the makers of cheap imitations: "They know not what they do." Literally that is true.

I have known an imitating lathe maker, who really thought that his product was as good as the thing he was imitating and insisted that the higher price asked for that original was nothing more nor less than a bonus paid for a firm name and reputation. He was incapable of understanding the value of a "know how," and not well enough versed in his own business to know that he did not know and that he did not have the "know how" to turn out a high class article.

Bargain counter machines are usually expensive in the end.

Yet what in the ultimate analysis is to be done? That is in some cases. Take this for example:

A railroad was anxious to use the best and most suitable material for a certain piece of work. For a number of years it had bought and specified a particular brand of metal. It limited the purchasing agent and the manufacturer and permitted them no latitude.

Then comes the manufacturer of another brand, asking for consideration, so it was decided to investigate. Straightaway the manufacturer of the brand that had been specified for so long a time, rises to the occasion and says that he makes something better suited to the work in hand than the brand used. So an investigation was made, in the course of which it developed that not only was the recommended brand of the old manufacturer better but so also was that of the newcomer.

Then, in order to secure a competition in prices, a specification was drawn, and a number of parties were asked for bids.

Now comes the purchasing agent who knows nothing of material, but does know prices. He has the specifications. Meet the specifications though your metal be of the pot variety, and the order is yours if your price is the lowest.

The specifications will protect the railroad against material that is positively unsuited for the work, but they will not secure that best suited.

The cook of a certain celebrated hostelry, concocted, a great many years ago, a very dainty roll. For years the secret of its preparation was guarded and meanwhile it gave an added reputation to its source. Every cook knew that it must contain proportions of flour and milk and butter and other things, but as to just how they were mixed in order to secure the results they were long in finding out.

Any metallurgical chemist can take any metal and, by careful analysis, tell of what it is composed. But it is quite another thing to tell how those ingredients or impurities are put together and how treated.

So with the case in hand. We all know that one brand would stand up to its work better than any other. That it would outlast any of its competitors. It would meet the specifications, and so would the others. It was beyond the ken of the officials to compile specifications that would admit this and exclude the others. Indeed they did not want to exclude competition. There was no known test, which it was feasible to make, that would set forth the virtues of this particular metal. Yet we all knew that, in the long run, taken day in and day out under the exigencies of hard service, that this particular brand was the best.

But its price was high and other brands could meet the specifications, and so the purchasing agent turned it down.

Evidently the only way out of such a dilemma is to either ignore the best and tie up to specifications, or specify the best brand, discard competition and pay the price to the man who has the "know how" tucked away in the back of his brain.

There is also this about it, that the man with the "know how" is usually proud of it and rather careful that his acts and products shall be up to the standard of his best. So that he is likely to be far more dependable, and apt to hold to the high standards which he has established than is the man who has never established high standards, and whose "know how" is a little wobbly.

The moral of all of which is that, if you want the best, be willing to pay for the "know how" and don't grumble about or stick at the price.

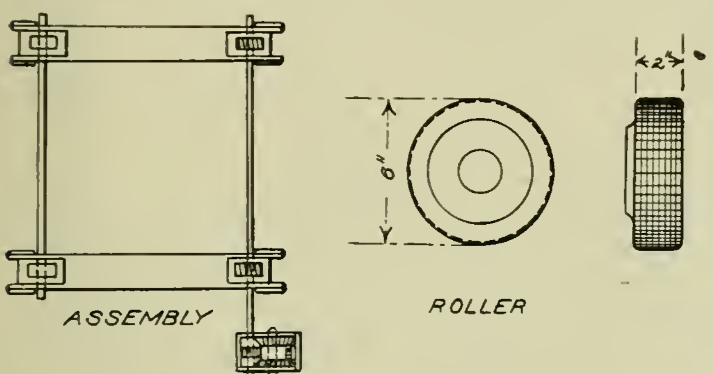
Shop Kinks

Some Tools and Devices in Use on the Delaware & Hudson, Chesapeake & Ohio, and Erie Railroads That Facilitate Shop Work

Valve Setting Machine

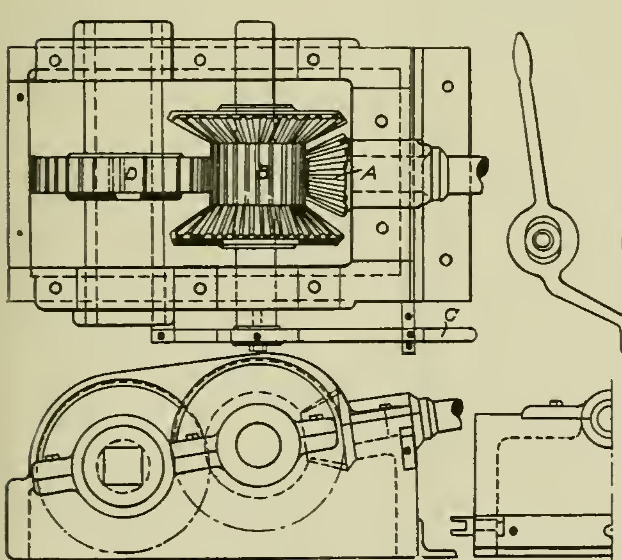
The interest in this machine lies in the gear box. The machine itself, that is, the roller portion on which the wheels rest and by which they are turned, consists of the usual set of four rollers mounted in a frame that rests on the rails, and which may be drawn together by screws so that the wheels are lifted clear of rails.

Instead of the old hand-operated lever, an electric or air motor has been substituted as a driver, and this necessitates a gear box for reversing the motion or reducing the speed of rotation. Where a single direction motor is used, the gear box having beveled gears may be used.



Valve Gear Setting Machine

In this the shank carrying the beveled pinion A is connected with the motor. Running at right angles to this shank is a shaft carrying two beveled years and a long spur pinion B. At the outer end of the shaft, at one end, there is a collar forming a groove in which the reverse lever C sets and by which the shaft may be given a travel in the direction of its axis, thus throwing one or the other of the beveled gears into mesh with the pinion and so reversing the motion of the shaft itself.


Gear Box for Valve Setting Machine

The spur pinion B C with the long face is always in mesh with the spur gear D which is keyed to the driving roller shaft, and the face of this is narrow enough to permit the shifting of the pinion B without interference or striking the beveled gears.

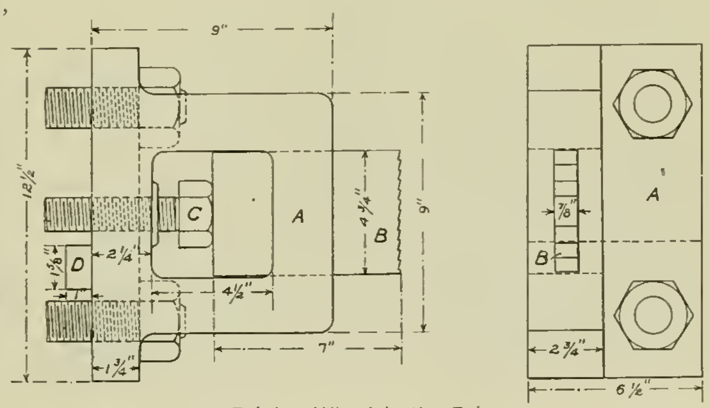
Where a reversing motor is available it is simply necessary to have a train of gears in the box that will make a suitable reduction of the rate of rotation. A gear box containing such a train of gears is shown. In this the main shaft terminates in a No. 5 Morse taper spindle and carries a pinion 3 in. in diameter having 16 teeth, this meshes with a gear on the intermediate shaft which is 6¾ in. in diameter and has 36 teeth. On the same shaft is keyed a pinion similar to the first driving pinion, and this meshes with a gear 7½ in. in diameter having 40 teeth on the roller shaft. This divides the speed of the motor by 5⅝, which is the ratio of the relative speeds of the motor and roller.

The gears have a face of 1 15-16 in. and are housed in a substantial cast iron box 1½ in. thick. At one end an L-shaped piece of steel plate 7 in. wide is bolted by which the housing may be fastened to the floor.

Driver for Driving Wheel Lathe

This very simple driver, which is intended to be bolted to the face plate of a driving wheel lathe, is one which is in use in the shops of the Delaware & Hudson Co. at Watervliet, N. Y.

Three or four of these drivers are bolted to each face plate at equal angular intervals apart and in line with the tire. The body A is finished on its face and bolted securely in place by two 1½ in. diameter bolts. It is of a general L-shaped and, in the leg of the L, there is a slot in which the driver dog B is inserted. This is of 4¾ in. by ⅞ in. steel serrated on its bearing face and hardened so that it will cut into the metal of the wheel. It is forced out against the wheel by the head of the stud C which is screwed into the body and can be backed out against the dog. The slight amount of play which the dog has in the slot allows it to dig into the metal of the wheel as the driving



Driving Wheel Lathe Drivers

stress is put upon it by the cut, and thus hold it securely without turning.

The lug D fits into one of the radial slots in the face plate and serves to take the shearing stresses off from the bolts by which the driver is held in place.

Pneumatic Press for Straightening Parts of Steel Cars

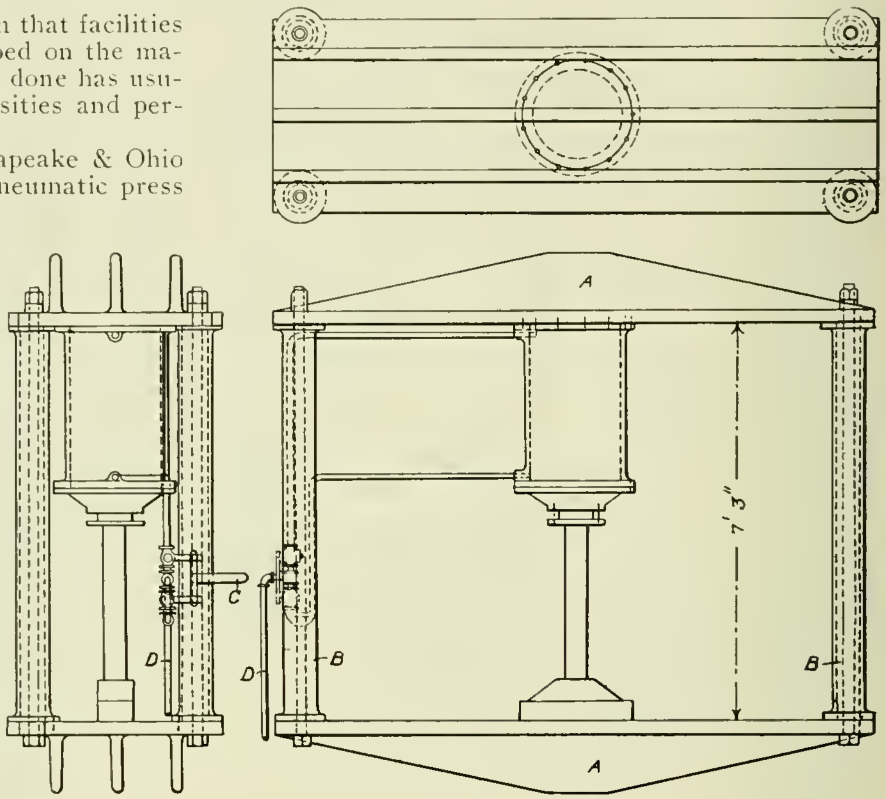
The steel car has so come into its own that facilities for effecting repairs have been developed on the majority of the railroads. What has been done has usually been dictated by immediate necessities and personal experience.

At the Richmond shops of the Chesapeake & Ohio Railway they have built a powerful pneumatic press for straightening the parts of these cars. It is entirely self-contained, so that, as far as its operation is concerned, it is independent of any foundation upon which it may be placed. The base and top pieces A A are of cast iron made from the same pattern, and are tied together by four bolts each 2¼ in. in diameter passing through a corresponding number of separator castings B.

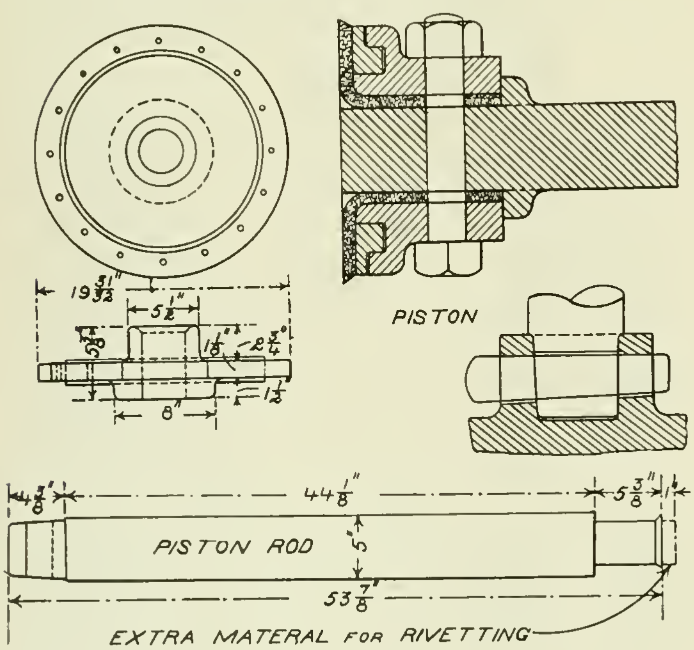
The tables of the pieces A are finished on the flat as are the ends of the separator castings. The pieces A have a total width of 3 ft. 6½ in. with a round-out of 2⅜ in. at each corner to take the end of the separators. The tables are 3 in. thick on the flat and are stiffened by three ribs, as shown by the end elevation, each 2½ in. thick and 12½ in. deep.

The separators are 7¼ in. outside diameter and 5¾ in. on the inside, and are 7 ft. 3 in. long.

The cylinder is a simple iron casting of 20 in. internal diameter and is bolted to the upper cross piece A, whose bottom face forms its head, by thirteen ¾ in. studs. The lower end of the cylinder is closed with a plain head fitted with the usual stuffing box to hold the packing.



Pneumatic Press for Straightening the Parts of Steel Cars



Details of Piston and Rod of Pneumatic Press for Straightening the Parts of Steel Cars

The piston rod is 5 in. in diameter and is keyed to the head with a ⅝ in. by 2 in. key. It is turned to 3½ in. in diameter for the fit to the piston and is rivetted over; sufficient material being left for this purpose on the end.

The piston is of cast iron and consists of a plain flat disc 1½ in. thick with a boss on each side at the center. On one side it is 8 in. in diameter and 1½ in. high and on the other side it is 5½ in. in diameter and 2¾ in. high, thus forming a total length of seat for the piston rod of 5⅜ in.

The piston is packed with two cup leather packing rings held in place, as shown, by bull rings on either side of the piston disc, and forced out against the walls of the cylinder by spring rings.

The operation of the press is effected by two 1¼ in. cut-out cocks whose handles are coupled together by a link to which an operating handle C is attached.

Compressed air from the source of supply is led to a tee between the two cocks by way of the pipe D. Pipes then lead from the two cocks to the inlets tapped in to the top and bottom of the cylinder, respectively.

When the handle C is in the central position, as shown in the engraving, the flow of air is cut off to and from both ends of the cylinder. If it is moved in one direction the air is admitted to the top of the cylinder and exhausted from the bottom. If it is moved in the opposite direction the reverse action takes place.

With a cylinder diameter of 20 in. and an air pressure of 60 lbs. per sq. in., a pressure of about 18,850 lbs. may be brought to bear upon the work.

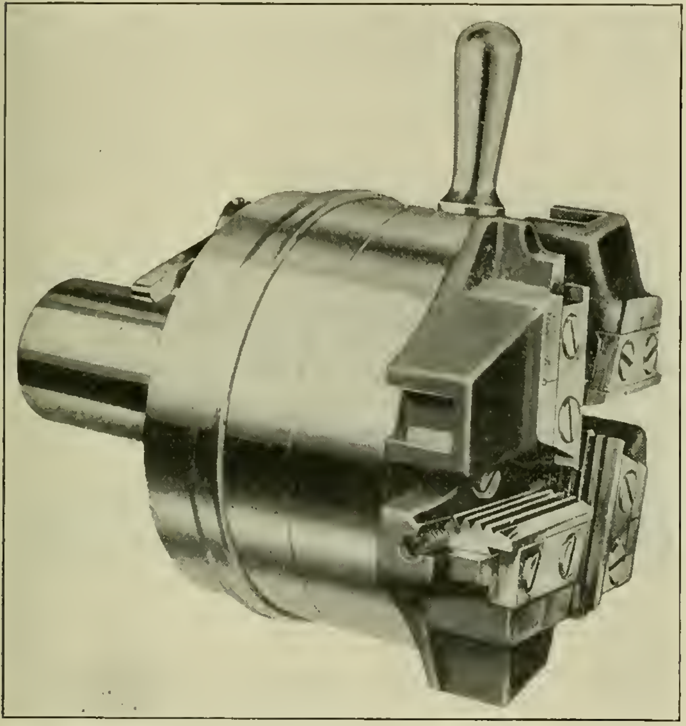
As the longitudinal distance between the centers of the holding bolts is 10 ft. ¾ in. and the lateral distance 3 ft., almost any part belonging to an ordinary car may be worked in the press, and its power is sufficient to straighten any plate work cold and the heavier parts when heated.

The Land-matic Die Head

The Landis Machine Company, Waynesboro, Pa., manufacturers of thread cutting equipment, have given a name to the Landis automatic die head which is applied to turret lathes and hand operated screw machines. In the future this head will be known as the Land-Matic die head, A brief description of which follows:

The chasers are supported on the face of the head. This permits of easy access to the chasers when it is necessary to remove them for grinding and changing from one size to another. It is made of steel and its sturdy construction insures a long life of hard service. The head is applicable to practically all makes of screw machines and turret lathes which have sufficient space to swing heads of these diameters.

The head is opened automatically by retarding the forward motion of the carriage and is closed by hand.



New Land-matic Die Head

It is locked by the engagement of two hardened cylindrical lock pins in hardened bushings. The roughing and finishing cuts are obtained on the 1¼ in., 2 in. and 3 in. heads by the movements of the lock pin lever. When cutting threads in one pass, both lock pins are engaged. When cutting threads in two passes, both lock pins are engaged during the first cut and for the second cut, one lock pin is engaged. This is controlled by the lock pin lever.

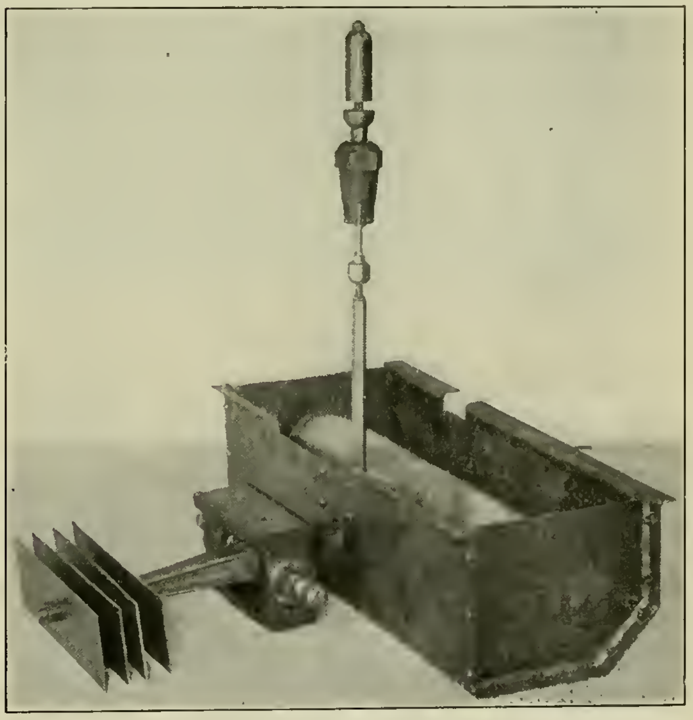
The head is adjusted to size by means of an adjusting screw which engages the head body. Since the operating, adjusting and closing rings remain in a fixed position when the head is closed, the rotating of the head body within these rings gives the diameters within the range of the head. It is graduated for all sizes of bolts, both right and left hand, and right hand pipe within its range. To adjust the 1¼ in., 2 in. and 3 in. heads for left hand threading, reverse the position of the lock pin lever in relation to its position for right hand threading.

The chaser holders and trunnions on the ⅝ in. and ⅞ in. automatic heads are integral. The one set of chaser holders furnished with the head will be suitable for threading bolts and pipe within its range. When pitches and diameters other than U. S., "V.," S. I., Whitworth and Briggs Standards are to be threaded, special chaser holders with trunnions integral will be supplied. The chaser holder and trunnion may be easily removed from the die head by merely removing the shank and loosening one screw. These heads are not equipped with roughing and finishing attachments.

The chaser holders and trunnions furnished with the 1¼ in., 2 in. and 3 in. Automatic Die Heads are separate. Unless otherwise specified the die heads will be furnished with right hand bolt chaser holders for cutting U. S. Standard diameters and pitches. If these heads will be required for threading pipe, for cutting S. A. E. diameters and pitches, or diameters and pitches other than U. S., "V.," S. I., Whitworth and Briggs standards, the proper chaser holders will be supplied. These heads are equipped with roughing and finishing attachments. This type of head employs the Landis long life chaser. These heads will be furnished with shanks to meet individual requirements.

Security Low Water Alarm

A new low water alarm, differing in principle from other devices of this character, is the Security Low Water Alarm, made by the United States Metallic Packing Company, 429 North 13th Street, Philadelphia.



The Security Low Water Alarm

Security Low Water Alarm employs no fusible plugs of any kind. It is actuated solely by the height of solid water over the crown sheet.

A cylindrical buoyant float is secured to the end of a rocker arm. This rocker arm is pivoted in a bracket so that the cylindrical float can rise and fall by its buoyancy with variation in the water level of the locomotive boiler. The bracket which supports the rocker arm is located so that the center of the pivots is 5 in. above the crown sheet. If the water in the boiler is more than 5 in. above the crown sheet the float is submerged, as it cannot rise above this point due to the needle valve which enters the whistle and makes a joint, and which prevents the float from rising at a point higher than 5 in. above the crown sheet. When the water in the boiler is reduced to a height less than 5 in. above the crown sheet the float resting on the surface of water will fall with the water as the level in the boiler becomes lower and the weight of the float will pull the needle valve away from the seat in the whistle. This sounds the warning calling the engineer's attention to the low water condition.

The cylindrical float which controls the sounding of the whistle is encased in a sheet iron baffle box. The purpose of this baffle box is to break up any surging or pyramiding of the water so that the whistle will not sound unless there is an actual condition of low water in the boiler.

Secured to the balance lever on the opposite side from the cylindrical float is a series of plates. These plates present the same area of surface for corrosion as the area presented by the cylindrical float so that any corrosion or scale formation will be equalized on both sides of the brackets in which the device pivots.

Gasoline Train for Louisiana Southern Railroad

The Louisiana Southern Railroad has put into service a two-car gasoline train. This train was manufactured by the Four Wheel Drive Auto Company of Clintonville, Wisconsin. The train makes daily trips between New Orleans and Shell Beach, a distance of about 40 miles, and has accommodations to seat 67 passengers.

The power plant is a 4-cylinder T head motor of 42 H.P. SAE—68 on brake test. The bore of the motor is 5.1 in. with a stroke of 5.5 in. An Eisemann high tension magneto with impulse starter furnishes the braking system. Cast iron shoe brakes are used on each wheel of the power unit and trailer, there being one brake shoe for each wheel. A Westinghouse air brake system is provided to operate these brake shoes and to provide air, a Westinghouse air compressor is installed at the rear of the transmission. This air compressor is of 10 cu. ft. per minute capacity and is controlled by an automatic governor.

For starting and on steep grades one sand box is placed on the rear of each rear wheel and the front of each front wheel of the power unit. The flow of

Two-Car Gasoline Motor Train on the Louisiana Southern Railroad

ignition. The carburetor is a Stromberg plain tube. A 30-gallon tank mounted on the side of the chassis carries the gasoline supply. The gasoline is fed by air pressure; the air pressure being applied through the reducer valve from the air brake system. The transmission is of the jaw clutch type with gears always in mesh. There are four speeds forward and four speeds reverse.

One of the special features is the four wheel drive principle. The weight of the tractor unit is equally distributed to the four driving wheels of the tractor unit, thus furnishing that great amount of traction that is required for starting and for negotiating grades.

The springs are 54 inches long 2½ inches wide and made of chrome silicon manganese steel heat treated. Four of the springs being used on the chassis of the power unit and trailer. These springs are connected to the chassis frame with double swing shackles which allows the chassis to swing slightly sidewise, thus cushioning the side impacts against the rail and improving the riding qualities of the car. The action of these shackles is very similar to that of the swinging bolster used in railroad cars. The axles are held in place and alignment by radius rods. By the adjustment of these radius rods the wheels can be brought into perfect alignment.

Another special feature of the gasoline train is the sand from these boxes is governed by an air valve at the driver's seat. Air is provided for the operation of these sanders by the air brake system.

To facilitate switching from one division to another standard MCB couplers are installed both at the front and the rear of both cars.

A two unit starting and lighting system is furnished consisting of a starting motor which operates on the fly wheel of the engine through a Bendix drive. A 270 Watt generator and a 225 ampere hour storage battery. The voltage of this system is 12 volts.

The train is divided into three compartments—the passenger compartment, the smoking section and the motorman's and baggage compartment. The trailer coach, which is used wholly for passengers, will comfortably accommodate 40 passengers; the smoking section will seat 16 people and the baggage compartment has auxiliary seats for 11 passengers.

The length of the bodies is approximately 26 ft. The height inside from top of floor to ceiling is 6 ft. 8 in. The bodies are of wood construction. The roof is plain arched, extending the full length of body. The material is of tongued and grooved poplar covered with No. 8 canvas bedded in white lead. The windows are of the double sash type with the top sash stationary and continuous with the lower sash to raise. The inside of the cars are finished in cherry stained mahogany.

Notes on Domestic Railroads

Locomotives

The New York Central Railroad has ordered 61 Mikado type locomotives from the American Locomotive Company and 40 Mikado type locomotives from the Lima Locomotive Works.

The Southern Railway is reported to be inquiring for 25 locomotives.

The Canadian National Railways has ordered from the Montreal Locomotive Works, Ltd., 30 Mikado type, 15 Mountain type and 5 Santa Fe type.

The Indiana Harbor Belt Railroad is reported to be inquiring for 10 Mikado type locomotives.

The Maine Central Railroad has ordered 6 Mikado type and 2 Pacific type locomotives from the American Locomotive Company.

The Louisville & Nashville Railroad is inquiring for 18 Mikado type, 6 Pacific and 6 switching type locomotives.

The Maine Central Railroad has ordered 6 Mikado type and 2 Pacific type locomotives from the American Locomotive Company.

The International-Great Northern Railroad has ordered 6 Mikado type locomotives from the Baldwin Locomotive Works.

The Lincoln Sand & Gravel Company of Chicago has ordered one switching type locomotive from the Baldwin Locomotive Works.

The Pittsburgh & West Virginia Railway is reported to be inquiring for one Mikado type locomotive.

The Cleveland, Cincinnati, Chicago & St. Louis Railway is preparing preliminary plans covering the construction of a brick and concrete engine terminal at Cincinnati, Ohio.

The Atchison, Topeka, & Santa Fe Railway is reported to be planning the construction of car and locomotive shops and other facilities at Cleburne, Texas, at estimated cost of $3,000,000.

The Norfolk & Western Railway is preparing plans covering the construction of machine shop at Portsmouth, Ohio.

The Louisville & Nashville Railroad is reported to be planning the construction of additional yards, roundhouse, car and locomotive repair shops at New Orleans, La.

The Atlantic Coast Line Railroad has awarded contracts for the erection of additional shops at Montgomery, Ala. This includes the replacement of shops recently destroyed by fire, and the erection of a car shop, engine shop, roundhouse and other buildings.

The Missouri, Kansas & Texas Railway is planning the construction of a one-story brick and steel freight car repair shop, at Denison, Texas, estimated to cost $180,000.

The Texas & New Orleans Railway has purchased 32 acres of land at Jacksonville, Texas, at a cost of $16,000, and will construct thereon repair shops, roundhouses and yard facilities.

The Cleveland, Cincinnati, Chicago & St. Louis Railway plans an addition to its roundhouse at Sharonville, Ohio, at an estimated cost of $100,000.

The Philadelphia Slag Company has ordered one switching type locomotive from the Baldwin Locomotive Works.

The Detroit, Toledo & Ironton Railroad is inquiring for 4 switching type locomotives.

The Charcoal Iron Company has ordered one Mogul type locomotive from the Baldwin Locomotive Works.

The Tatuem Lumber Company has ordered one Mikado type locomotive from the Baldwin Locomotive Works.

The Diamond & Calder Railway has ordered one Shay type locomotive from the Lima Locomotive Works.

The Union Pacific Railroad is reported to be in the market for 25 locomotives.

The Cia. Mogyana de Estrados de Ferro, Brazil, has ordered 6 Mikado type and 2 Pacific type locomotives from the American Locomotive Company.

The Union Railroad has ordered 2 switching type locomotives from the American Locomotive Company.

The New York Central Railroad has placed an order for 35 switchers with the American Locomotive Company and for the same number with the Lima Locomotive Works.

The Illinois Central Railroad is reported to be inquiring for 10 locomotives.

The New York, Chicago & St. Louis Railroad is reported to be inquiring for 20 locomotives. 10 Mikado and 10 switching type locomotives.

The Atlantic Coast Line Railway is reported to be inquiring for 25 locomotives.

The Florida East Coast Railway is reported to be inquiring for 25 locomotives.

The Seaboard Air Line Railway is reported to be inquiring for 30 locomotives.

The Chicago, Rock Island & Pacific Railway is reported to be inquiring for 10 locomotives.

The Bridgton & Saco River Railway has placed an order for one locomotive with the Baldwin Locomotive Works.

The Meadowfield Lumber Company of Pennsylvania is in the market for 2 locomotives.

Freight Cars

The Louisville & Nashville Railroad is inquiring for 1,650 single sheathed box cars, 1,000 single sheathed automobile cars, 1,100 composite drop bottom gondola cars, 1,100 steel drop bottom gondola cars and 150 steel underframe flat cars.

The Delaware, Lackawanna & Western Railroad contemplates buying 500 automobile cars.

The Denver & Rio Grande Western Railroad is inquiring for 500, 40-ton automobile cars.

The Norfolk & Western Railway has ordered 1,000 cars from the Standard Steel Car Company and 1,000 cars from the Bethlehem Steel Company.

The Central of Georgia Railway contemplates having repairs made to 100 steel underframes.

The Union Railroad is inquiring for 1,000 hopper cars of 55-tons capacity.

The Missouri Pacific Railroad is inquiring for 1,000 single sheathed automobile cars.

The Atchison, Topeka & Santa Fe Railway has ordered 500 gondola cars from the American Car & Foundry Company, and 1,000 box cars and 500 automobile cars from the Pullman Company.

The Pennsylvania Railroad is reported to be in the market for 9,000 freight cars.

The New York Central Railroad has ordered 2,000 freight cars from the American Car & Foundry Company, 2,000 from the Standard Steel Car Company, and 1,000 refrigerator cars from the Merchants Dispatch.

The El Paso & Southwestern Railway has ordered 400 box cars of 50-tons capacity from the Standard Steel Car Company.

The Fruit Growers Express has ordered 500 steel underframes for refrigerator cars from the Western Steel Car & Foundry Company.

The Norfolk & Western Railway has ordered 2,000 steel hopper cars of 70-tons capacity from the Ralston Steel Car Company, 1,000 from the Pressed Steel Car Company, and 1,000 from the Virginia Bridge & Iron Company.

The Union Refrigerator Company has ordered 3 underframes from the American Car & Foundry Company.

The National Tube Company is inquiring for 50 steel hopper car bodies of the 70-tons capacity and for 25 steel flat cars of 50-tons capacity.

The Empire Oil Works is reported to be in the market for 370 tank cars.

The Louisville & Nashville Railroad is reported to be inquiring for 4,000 freight cars.

The Atchison, Topeka & Santa Fe Railway contemplates buying 500 stock cars and 500 flat cars.

The Lehigh Valley Railroad has given a contract for making repairs to 300 box cars to the American Car & Foundry Company.

H. L. Doherty & Co., New York City, has ordered 370 tank cars from the American Car & Foundry Company.

The East Jersey Railroad & Terminal Co. has ordered 64, 10,000 gal. tank cars from the American Car & Foundry Company.

The Atchison, Topeka & Santa Fe Railway has ordered 500, 40-ton flat cars from the American Car & Foundry Company.

The Canadian National Railways is inquiring for 1,000 box cars and 150 Hart convertible cars, 500 general service cars and 50 caboose cars.

The Missouri Pacific Railroad is inquiring for repairs on 1,150 cars as follows: 500 box cars, 300 steel gondola cars and 250 composite gondola cars.

The Spokane, Portland & Seattle Railway has ordered 60 logging cars from the Magor Car Corporation.

The Union Pacific Transit Company, Milwaukee, Wis., is contemplating building 300 refrigerator cars in its own shops.

The Cincinnati Northern Railroad has ordered 500 box cars from the American Car & Foundry Company.

The Union Pacific Railroad has ordered 250 tank cars from the General American Tank Car Company.

The Atlantic Coast Line Railroad is inquiring for 75 steel underframes for caboose cars.

The Maine Central Railroad has ordered 100 gondola cars from the Standard Steel Car Company, and 250 box cars from the Laconia Car Company.

The Northern Pacific Railway has ordered 200 steel cars of 75 tons capacity from the Pressed Steel Car Company.

The New York Central Railroad has given contracts to the Pennsylvania Car Company & Youngstown Steel Car Company for the repair of 500 flat cars each.

The Carnegie Steel Company is inquiring for 15 tank cars of 12,500 gal. capacity.

The New York Central Railroad has ordered 3,500, 70-ton hopper cars from the American Car & Foundry Company, 1,500, 70-ton hopper cars and 1,000 automobile cars from the Pressed Steel Car Company, and 3,500, 70-ton hopper cars from the Standard Steel Car Company.

Passenger Cars

The Maine Central Railroad has ordered 6 coaches, 3 smoking cars and 4 baggage and mail cars from the Standard Steel Car Company.

The New York, New Haven & Hartford Railroad has ordered 10 gasoline motor cars from the Sykes Company, Winthrop Harbor, Ill. These cars will have a seating capacity of 45 passengers and will be equipped with baggage compartments.

The Atlantic Coast Line Railroad is inquiring for 10 express cars and 7 combination mail and baggage cars.

The New York, Chicago & St. Louis Railroad is inquiring for 4 baggage cars 3 coaches and 1 dining car.

The Chicago Great Western Railroad has ordered a new type gas-electric passenger car from the General Electric Company.

The Northern Pacific Railroad is inquiring for 10 all-steel baggage cars.

The Southern Pacific Co. has ordered 15 dining cars from the Pullman Company, 23 baggage cars from the Bethlehem Shipbuilding Corporation, 6 baggage horse cars and 6 baggage buffet cars from the American Car & Foundry Company.

The New York Central Railroad has ordered 80 baggage cars and 15 coaches from the American Car & Foundry Company, 23 combination passenger and baggage cars from the Pressed Steel Car Company; 50 coaches and 15 dining cars from the Pullman Company and 50 coaches from the Standard Steel Car Company.

The Lehigh & Hudson River Railway has ordered 10 refrigerator milk cars from the American Car & Foundry Company.

The Chicago, Burlington & Quincy Railroad is inquiring for 25 baggage cars and 5 combination baggage and mail cars.

The Florida East Coast Railway contemplates buying 10 passenger service cars.

The Southern Pacific Company contemplates buying 23 passenger cars.

The Atchison, Topeka & Santa Fe Railway is inquiring for 10 smoking cars, 10 chair cars and 10 coaches, 10-3 compartment cars and 6 business cars.

The Minneapolis, St. Paul & Sault Ste. Marie Railway is inquiring for 25 milk cars.

The Canadian National Railways is inquiring for 20 baggage cars, 20 coaches, 15 combination baggage and mail cars and 10 parlor cars.

The Pacific Electric Railway is in the market for 62 passenger cars of various types.

The New York Rapid Transit Co. is in the market for 148 car bodies and underframes.

The Great Northern Railway is inquiring for 50 express-refrigerator cars.

The Canadian National Railways have ordered 24 coaches from the Canadian Car & Foundry Company, and 11 baggage cars from the National Steel Car Company.

The Nashville, Chattanooga & St. Louis Railway has ordered 1 gasoline car from the J. G. Brill Co.

The Central Railway of Brazil is inquiring for 12 sleeping cars, 12 coaches, 6 steel baggage cars and 6 steel mail cars also sleeping cars narrow gauge.

The Sao Paulo Railway, Brazil, is in the market for 10 first class passenger cars.

The Southern Pacific Railroad Co. is inquiring for 23 passenger cars, as follows: 10 interurban coaches, 4 coaches, 5 chair cars, and 4 baggage-mail cars.

Buildings and Structures

The Louisville & Nashville Ry. is planning the construction of a roundhouse at Whitesburg, Ky., at an estimated cost of $50,000.

The Great Northern Railway plans the construction of a 30-stall roundhouse at Troy, Mont.

The Union Pacific Railroad plans the construction of an 11-stall brick addition to its roundhouse at Los Angeles, Calif., at an estimated cost of $70,000.

The Missouri-Kansas-Texas Railroad is reported to be planning the construction of a one-story car repair shop at Denison, Texas, at an estimated cost of $175,000.

The Louisville & Nashville Railway has let a contract covering the construction of a one-story steel and concrete machine shop at Etowah, Tenn., at an estimated cost of $100,000.

The Chicago, Burlington & Quincy Railroad is calling for bids for the construction of a 5-stall addition to its roundhouse at Edgemont, S. D., and a 5-stall addition to its roundhouse at Denver, Colo.

The Canadian Pacific Railway will rebuild its roundhouse at Schreiber, Ont., which was destroyed by fire. The new building will be one-story, will be reinforced concrete and brick, and the estimated cost will be $25,000.

The Southern Railway is reported to be planning the construction of car repair shops at Spartanburg, S. C. The estimated cost will be $200,000.

Items of Personal Interest

T. F. Barton of the Chesapeake & Ohio Railway has been appointed general master mechanic of the Western division with headquarters at Huntington, W. Va. **G. H. Langton** has been appointed to a similar position on the eastern division with headquarters at Clifton Forge, W. Va.

J. A. Sheedy of the Pennsylvania Railroad has been appointed master mechanic with headquarters at Meadows, N. J.

O. P. Reese, superintendent of motive power of the Pennsylvania Railroad with headquarters at Chicago, has been appointed assistant general superintendent of motive power with headquarters at Ft. Wayne, Ind.

W. G. Seibert, general master mechanic of the Missouri Pacific Railroad with headquarters at Kansas City, Mo., has been promoted to assistant mechanical superintendent with the same headquarters.

G. B. Fravel, superintendent of motive power of the Pennsylvania Railroad with headquarters at Columbus, Ohio, has been appointed assistant general superintendent of motive power with headquarters at St. Louis, Mo.

W. E. Dunham, assistant to the general superintendent of motive power of the Chicago & North Western Railway with headquarters at Chicago, has been promoted to superintendent of the car department with the same headquarters, succeeding **T. H. Goodnow**, resigned.

J. Stockton, of the New Orleans Terminal Co., has been appointed master mechanic, the position of general foreman having been abolished.

G. K. Stewart of the Missouri Pacific Railroad has been appointed master mechanic of the Northern Kansas division with headquarters at Atchison, Kansas. **C. R. Kilbury** has been appointed master mechanic of the Southern Kansas division with headquarters at Coffeyville, Kansas, succeeding Mr. Stewart. **O. W. Judd** has been appointed master mechanic of the White River division with headquarters at Crane, Mo. **H. W. Reinhardt** has been appointed master mechanic of the Missouri division with headquarters at Poplar Bluff, Mo.

S. E. Mitchell, chief draftsman in the mechanical department of the Chicago & North Western Railway with headquarters at Chicago, has been promoted to assistant to the general superintendent of motive power, same headquarters, succeeding **W. E. Dunham**.

A. G. Greenseth of the Minneapolis, St. Paul & Sault Ste. Marie Railway has been appointed master mechanic of the Minnesota division with headquarters at Enderlin, N. D., succeeding **S. N. Woodruff**, retired.

C. G. Fluhr of the Atchison, Topeka & Santa Fe Railway has been appointed superintendent of the Arizona division with headquarters at Needles, Calif.

S. O. Taylor of the Missouri Pacific Railroad has been appointed master car builder with headquarters at St. Louis, Mo. Mr. Taylor was formerly with the American Railway Association at Chicago, Ill.

R. H. Hale has been appointed master mechanic of the Alaska Railroad with headquarters at Anchorage, Alaska, succeeding **F. C. Ferrell**, resigned.

L. A. Mitchell has been appointed master mechanic of the East Bay division of the Southern Pacific Co. with headquarters at West Alameda, Calif., succeeding **J. H. Lockett**, deceased.

J. P. Downs, superintendent of shops of the Missouri Pacific Railroad at Sedalia, Mo., has been promoted to assistant mechanical superintendent, with headquarters at Little Rock, Ark.

J. Herron, superintendent of motive power of the Duluth, South Shore & Atlantic, has resigned, and M. J. Dunnebacke has been appointed master mechanic at Marquette, Mich. The office of superintendent of motive power and machinery has been abolished.

Supply Trade Notes

Electric Storage Battery Co. has assigned **E. I. Lord** to handle the railway sales with headquarters at San Francisco, Calif. Mr. Lord was sales engineer of the Electric Storage Battery Co.

Pennsylvania Tank Car Co., Sharon, Pa., has changed its name to **Pennsylvania Car Co.**, this change being made in view of its increased scope of carbuilding activities.

Hale-Kilburn Co., Philadelphia, Pa., manufacturer of car seats, proposes considerable enlargement and increased scope of activities. **Charles M. Schwab** has recently been elected chairman of the board of directors of this company.

McConway & Torley Co., Pittsburgh, Pa., is making addition to its plant at that point, which plant manufactures the Jenny car coupling.

William M. Ryan has resigned as president of the **Ryan Car Co.**, and **J. M. Hopkins**, chairman of the board of the **Camel Co.**, succeeded Mr. Ryan. **T. H. Goodnow**, superintendent of the Chicago & Northwestern Railway, has been appointed vice-president of the Ryan Car Co., with headquarters at Chicago, Ill.

Standard Tank Car Co., Sharon, Pa., has elected **J. Bruce Orr**, Pittsburgh, Pa., president, succeeding **John Stevenson, Jr.** The new board includes **L. F. Payne**, representing the **Carnegie Steel Co.**, **R. F. Holmes** of the **Westinghouse Air Brake Co.**, **William Robinson** of Pittsburgh, Pa., **H. C. Rorick** of Toledo, Ohio, **E. Clarence Miller** of Philadelphia, Pa., and **J. P. Whitla** of Sharon, Pa.

Edwin B. Meissner was elected president and general manager of the **St. Louis Car Co.**, succeeding **John I. Beggs**, who has been made chairman of the board.

Mt. Vernon Car Mfg. Co., Mt. Vernon, Ill., will construct a one-story foundry at this point. The construction will be 202 by 258 ft. and will be of brick and steel.

Demster Equipment Co., Inc., Knoxville, Tenn., has been incorporated and will establish a plant to rebuild and repair locomotives, freight cars and cranes.

American Steel Foundries, Chicago, Ill., have added 150 men to their force at Alliance, Ohio, and expect to start another furnace sometime this month.

L. H. Welling has been appointed manager of the eastern office of the **Graver Corp.**, East Chicago, Ind., with headquarters at 5045 Grand Central Terminal, New York City.

Hanna Engineering Works, Chicago, Ill., has appointed **Walter F. Delaney** sales representative with headquarters at Richmond, Va.

C. Garness, mechanical engineer of the **American Car & Foundry Company** with headquarters at Chicago, Ill., has been appointed supervising engineer of the **Robert W. Hunt Company**, with headquarters at Chicago, Ill.

Westinghouse Electric & Mfg. Co. plans an addition to its plant at Essington, Pa., to cost $150,000. Also for the construction of a three-story factory estimated to cost $300,000 at Emeryville, Cal.

Frank J. O'Brien, vice-president and general manager of the **Globe Steel Tubes Company**, Milwaukee, Wis., has been elected president with the same headquarters to succeed **Paul J. Kalman** who has been elected chairman of the board of directors.

Safety Car Heating & Lighting Co. has appointed **Charles W. T. Stuart** representative with headquarters at Philadelphia, Pa. Mr. Stuart was previously foreman of car lighting of the Pennsylvania Railroad.

The National Car Wheel Company has been sold to the **American Brake Shoe & Foundry Co.**, New York. **Joseph B. Terbell** has been elected chairman of the National Car Wheel Company, succeeding **J. D. Rhodes**. **W. F. Cutler** has been elected president, succeeding **George P. Rhodes**. **F. C. Turner**, vice-president; **George M. Judd**, secretary; **Andrew Muirhead**, treasurer. All the other officers of the National Car Wheel Company remain as formerly.

The American Railway Car Co., Tigard, Oregon, plans the construction of a one-story building 60 by 400 ft. for the manufacture of a special type of gasoline car to be used on the railways. The plant, including equipment, to cost $60,000.

The Okonite Company, Passaic, New Jersey, has recently opened a branch office in the First National Bank building at Pittsburgh, Pa. This office is in charge of **Edward A. Damrau**, district manager.

The Pullman Company has purchased a 20 acre site at Seattle, Wash., and it is reported that it will erect a car plant there to take care of the northwestern territory.

Manning Maxwell & Moore, Inc., New York City, announce the consolidation of their Cincinnati and Cleveland offices. **E. H. Merrick** is to be manager of the consolidated offices with headquarters at Cleveland, Ohio.

The Railway Equipment Company of St. Louis, Mo., has been appointed to handle the business of the **National Lock Washer Company** of Newark, N. J., in southwestern territory.

Obituary

Dr. Plimmon H. Dudley, consulting engineer on rails, tires and structural steel of the New York Central, with headquarters in New York City, died in New York on February 25. Dr. Dudley was born at Freedom, Ohio, on May 21, 1843, and attended Franklin Institute. Later he received the degree of doctor of philosophy from Hirom (Ohio) College. His first railway service was with the Valley Railroad, a small line in Ohio, of which he was chief engineer from 1872 to 1874. From 1876 to 1878 he did special work for the Eastern Railroad Association. Mr. Dudley made a dynomometer car in 1874 and a track indicator in 1880. In 1883 he designed the first 5-in., 80-lb. steel rail used in the United States and, nine years later, designed the first 6-in., 100-lb. rail. Dr. Dudley had been consulting engineer for the New York Central since 1880, and, having made a life-long study of the properties of steel, has been recognized as one of the foremost authorities on the subject in the country.

John E. Fairbanks, general secretary and treasurer of the American Railway Association for the last eight years, and prominent in the activities of the association since 1909, died at his home in Jersey City, N. J., on February 24, after a short illness from pneumonia. Mr. Fairbanks was born in Jersey City on December 5, 1870, and was educated in that city. He entered the service of the American Railway Association on April 21, 1892, and on June 1, 1909, was appointed assistant general secretary and assistant treasurer; and was appointed general secretary and treasurer on November 17, 1915. While holding both of these offices, he held similar positions in the Bureau of Explosives, and was secretary of the General Managers' Association of New York. He also held similar titles in the Committee on Railway Mail Pay, and he had been clerk of the American Railway Guild for the past 25 years. Mr. Fairbanks served as a delegate of the American Railway Association at the International Congress in Rome, Italy, in 1922.

B. L. Knowles, manager of the publicity department of the Worthington Pump & Machinery Corpn., died February 14, as a result of a cerebral hemorrhage. Mr. Knowles had been in the service of the Worthington Corpn., for 28 years.

New Publications

Books, Bulletins, Catalogues, Etc.

A Century of Locomotive Building by Robert Stephenson & Co., 1832-1924, by J. G. H. Warren. Published by Andrew Reid & Co., Ltd., Akenside Hill, Newcastle-on-Tyne, England. 461 pages 11½x 8½ in.

Originally intended to record the history of a firm which has been building locomotives for one hundred years, this book has in fact a wider scope than its title may suggest, for the history of the firm of Robert Stephenson & Co. involves not only the history of the steam locomotive, but the life-stories of George and Robert Stephenson, and a study of their influence on its design.

The connection of these two men, in particular of George Stephenson, with the locomotive is universally known, and much has been written, though not always correctly, of their work in its development. Neither pretended to the invention of the locomotive, but both improved it, though a fresh study of material still available shows the part played by Robert Stephenson in stabilizing its design at a critical period was perhaps greater than has been hitherto realized, as also the part inevitably played by Robert Stephenson & Co., of which firm he was for thirty years the presiding genius.

Twenty-two of the thirty chapters into which the book is divided deal with the early development of the locomotive and the progress in England up until the death of Robert Stephenson. The story of the development during the succeeding period or until the present time is better known and requires less detailed treatment, but the concluding chapters describe and illustrate modern locomotives of different types and designs built by the firm.

The book has been based on original documents still in the possession of the descendants or families of two original partners, Edward Pease and George Stephenson, supplemented by other contemporary documents or information from English, French, German, Russian and American sources, some of the most important being now published for the first time.

The illustrations include reproductions in facsimile of original MSS., and of contemporary drawings and artistic representations, among them what is probably the earliest known picture of a steam rail locomotive. Many of these drawings have not only intrinsic merit but offer valuable evidence on questions of design hitherto in doubt, and in some cases have made it possible to supply with certainty links hitherto missing from the story of the evolution of the locomotive in its early stages.

Considerable reference has been made to some of the great controversies which affected the introduction and development of railways and locomotives, and it is now possible to review some of these from a fresh angle, and perhaps in a truer perspective. Some of the questions involved are today of merely academic interest, others remain fundamental and have a bearing on similar controversies now acute at home and abroad.

The book will be of interest on this account not only to the general reader and the operating engineer, but to the designer of locomotives, who may gather many lessons from the original working drawings now reproduced, supplemented as they are by diagrams summarizing the development of the locomotive, all to scale.

The student of early railway men and matters will find a large amount of information on a great variety of subjects, made easily available by an index of twenty pages. The work deserves to be treated as a noteworthy and highly valuable addition to the literature of the locomotive.

A Brief Outline of the Development and Progress of the Electric Railway Industry, is the title of a 54 page booklet recently issued by the Westinghouse Electric and Manufacturing Company.

This booklet sets forth in a brief and concise manner the history of the electric railway industry, from the installation of the first permanently fixed rails to the production of the powerful electric locomotives of today. A wealth of illustration, including photographs of modern equipment and sketches of the earliest railway apparatus, adds greatly to the interesting character of the publication.

In the introduction, "Reminiscences of Electric Railway Development," L. M. Aspinwall of the Westinghouse Company discusses the early trend of railway motor design and the problems encountered in the development of control apparatus.

Chapter 1 of the booklet includes the evolution of electric railway transportation from 1700 to 1885, describing the various inventions and experiments in the early stages of its history. This chapter is followed by a resume of the development and service of the Westinghouse Company in all branches of the electrical industry.

Chapters 3 and 4 recount the development of railway motors and control from the building of the first double reduction motor to the extensive equipment being manufactured today.

Electric railway history from 1894 to the present is set forth in the next chapter, after which a story of the first interurban railway in the United States is recounted. A discussion of freight haulage by the electric railway and the past and present tendencies of electric railway cars are included in the next chapters. Succeeding chapters in the publication portray the extensiveness of Westinghouse service and the methods of the company in rendering effective service to its customers through various works, offices, service stations and warehouses, and through engineering studies and many informative publications and advertising programs. Equipment maintenance and upkeep for electric roads is treated briefly in a four page discussion of that subject. A short description of the electric railway industry as it is today concluded the publication.

41,132 Locomotives Repaired Monthly in Last Six Months 1923

A report of the Interstate Commerce Commission to the President of the United States just made public shows that in the last six months of 1923 the railroads turned out of the railway repair shops of the country an average number of 41,132 locomotives monthly. A similar report of the Commission, made for the year 1921, shows that in the last six months of that year an average number of 22,106 locomotives were turned out of the shops. Similar figures for 1922 are not comparable because of the shop strike which began on July 1 of that year.

The average number of locomotives needing heavy and light repairs turned out monthly in the last six months of 1921 and 1923 were as follows:

	1921.	1923.
July	20,639	38,892
August	21,028	42,253
September	21,388	42,369
October	22,152	39,573
November	23,296	42,177
December	24,033	41,529
Totals	132,636	246,793
Monthly average	22,106	41,132

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XXXVII 114 Liberty Street, New York, April, 1924 No. 4

Result of Collision Between a Passenger Train and a Motor Truck

A Demonstration of the Danger to Railroad Trains of Reckless Automobile Driving

The illustration presented herewith is an aeroplane view of the results of an accident in which a passenger train, running at high speed, struck an automobile truck that was driven onto the tracks directly in front of the train.

The accident occurred on the Minneapolis, St. Paul & Saulte Ste. Marie Railway near Annandale, Minn., and resulted in the death of four people, two of whom were employes, and the injury of 35 passengers and four employes.

It was a case of the grossest carelessness on the part of the truck driver, who drove upon the track directly in front of the train. The circumstances were that the track at the crossing runs east and west, and just west of the highway crossing there was a switch leading to a passing siding. A freight train was standing on this siding well in the clear and with the locomotive headed east. As the highway approaches the track there is a clear view of the tracks to the east.

The passenger train consisted of 13 cars, some of wood and some of steel construction, with a mail and express car, a baggage car, and two steel coaches at the front in the order named. It was traveling at a speed of about 45 miles an hour when it struck the automobile oil-tank truck at the highway crossing, hurling it against and overturning and damaging the switch-stand to such an extent as to permit the switch-points to open. The engine and tender and the first truck of the mail car passed over this switch on the main track, but the rear truck

Photo by P. W. Hamilton.

Aeroplane View of Wreck on the Minneapolis, St. Paul & Saulte Ste. Marie Railway Caused by the Gross Carelessness of a Driver of a Motor Truck of the mail car and the following cars entered the siding. The train then separated between the mail and baggage cars, and the engine tender and mail car proceeded on the main track, with the rear truck of the mail car derailed, to a point about 800 feet west of the crossing where they came to a stop with the rear end of the mail car resting against a box car on the siding. The baggage car collided with the freight train and was practically demolished; it came to rest across both tracks and on top of the freight engine, which was overturned by the impact; the smoker, which was the first of the leading coaches, lay across the passing track with one end down the bank on the south side of the track, the forward portion crushed in by one of the following coaches. This coach together with a following tourist car remained upright parallel with tracks but derailed. Another coach and a second tourist car lay to the north and nearly clear of both tracks, the tourist car being overturned. The six rear cars remained on the track undamaged. One box car in the freight train was destroyed and five others damaged. The two employes killed were the engineman of the freight train and the baggageman of the passenger train. The other two persons killed were the driver of the truck and another man riding with him.

It appears, from the investigation that was made that after doing some work at the Annandale station, the freight train was moved down to the east end of the passing track. It was customary for the brakeman to get out on the crossing and flag, when any portion of a train was waiting close to a highway crossing and not blocking it, although there was no written rule to that effect, and so, after his train stopped the brakeman walked down to the engine, and the passenger train not being in sight, he sat on the rail until the train came around the curve about 2 miles east of Annandale; he then walked down toward the switch. He heard the engineer of the passenger train sound the whistle at the east mileboard and also heard the highway crossing whistle He had been there 5 or 6 minutes, and had noticed that the switch was securely locked in its proper position. While standing near the switch he saw the truck approaching on the highway, and at once proceeded to the middle of the road and signaled the approaching truck to stop. He estimated the truck was bout 225 feet distant from the crossing when he first began to signal and he repeated his stop signals four or five times, and thought the truck was running about 12 or 15 miles an hour. The driver and the man by his side appeared to be talking and laughing and paid no attention to him. When the truck driver was about 40 or 50 feet away, the brakeman saw him look toward the approaching passenger train then only a short distance away, and then he swerved to the left probably at the time seeing his danger. Knowing that an accident could not be avoided, he gave the engineer of the on-coming train an emergency stop signal, and jumped back to get out of the way of flying parts of the truck. He said he heard the emergency application of the brakes as the engine passed him. The truck seemed to be pushed forward by the engine and the engine and first part of the mail car passed safely over the switch. Then the points evidently became opened, allowing the rear trucks of the mail car to enter the passing track. They proceeded in this way until the connection between the mail and baggage cars was broken, and the baggage car collided with the engine of the freight train.

The first intimation that the engineer of the passenger train had of any possibility of danger was when he saw the brakeman of the freight train, apparently giving violent signals to someone on the opposite side of the track. His hand was already on his brake lever, when the fireman said, "You are going to hit a truck!" He made an emergency application of the brakes. It was not more than a second when he was splashed with gasoline from the truck which had been struck, and both the engineman and fireman were blinded for the time being. The engineman did not see the truck at any time. The bell on the engine, which was fitted with a bell ringer, was ringing at the time and was still ringing after the accident.

As a result of the inquiry, the conclusions reached were that this accident was caused by the driver of an automobile truck proceeding upon a highway and railroad crossing at grade directly in front of a passenger train which was approaching at high speed only a short distance away.

The truck driver and his companion were instantly killed when struck by the engine. The evidence, however, indicates that the truck driver paid no attention whatever to the stop signals given by the brakeman who was standing on the crossing, and that he did not look toward the east to see if there was an approaching westbound train until it was too late for him to stop.

In this open country it is not customary to protect highway crossings by flagman or by gates, and that in that state there are no laws requiring such protection. It is customary, however, for the trainmen as far as possible to protect train movements over road cossings, as was done by the brakeman in this instance. As was very properly stated in the findings of the Bureau of Safety, there can be no possible extenuation for such gross carelessness as was shown by the truck driver in failing to heed the stop signals given by the brakeman as well as in neglecting to look in both directions when approaching the crossing. Unless automobile drivers heed warning signs and flagmen's signals at railroad crossings, other accidents of this character may be expected to occur in the future.

New Basis Adopted for Reports of Locomotive Repairs

Owing to a change just placed in effect by the Car Service Division in the form used by the railroads in reporting locomotives in need of repair, comparisons with previous figures of the number of locomotives in need of both light and heavy repair on January 15th cannot be made. Under the change in form, the carriers are required to report, in addition to the locomotives in need of "running" repair, the number of locomotives in need of other repairs by classes as follows:

Class 1: New boiler or new back end. Flues new or reset. Tires turned or new. General repairs to machinery and tender.

Class 2: New firebox, or one or more shell courses, or roof sheet. Flues new or reset. Tires turned or new. General repairs to machinery and tender.

Class 3: Flues all new or reset. (Superheater flues may be accepted.) Tires turned or new. General repairs to machinery and tender.

Class 4: Flues part or full set. Light repairs to boiler or firebox. Tires turned or new. Necessary repairs to machinery and tender.

Class 5: Tires turned or new. Necessary repairs to boiler, machinery and tender, including one or more pairs of driving wheel bearings refitted.

In accordance with the revised form, reports showed 6,138 locomotives or 9½ per cent of the ownership in need of classified repairs and 5,302 locomotives or 8.1 per cent in need of "running" repairs.

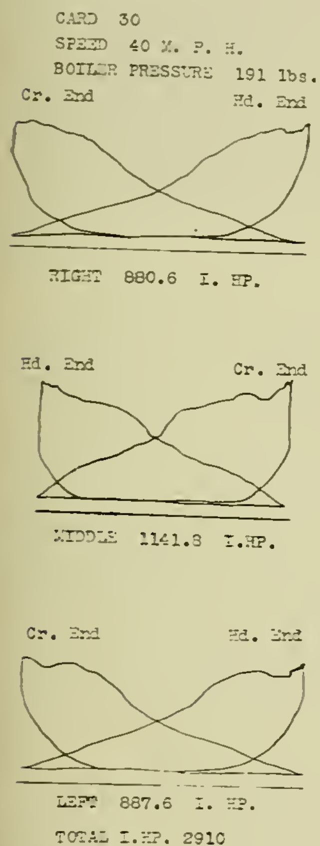
During the first fifteen days in January 21,004 locomotives were repaired and turned out of the shops, an increase of 1,203 compared with the last half of December, according to reports filed by the carriers with the Car Service Division of the American Railway Association.

Test of Three Cylinder Locomotive Number 5000

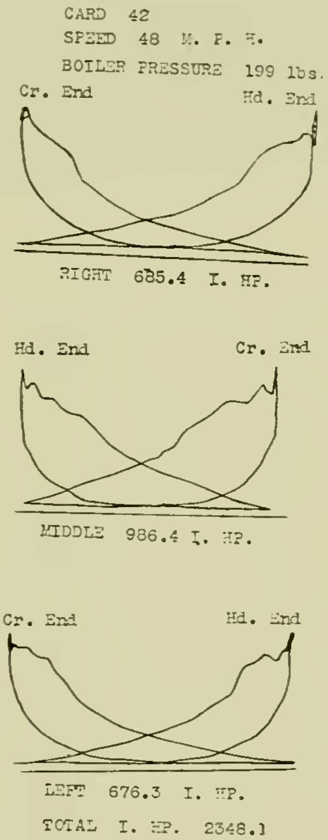
Conducted Under the Direction of W. I. Cantley, Mechanical Engineer, Lehigh Valley Railroad.

While the three cylinder type of locomotive has received some attention from American designers in the past, the complications of the valve gear, and the traditional prejudice against the crank axle deterred them from making any serious attempt to develop such an engine for heavy duty.

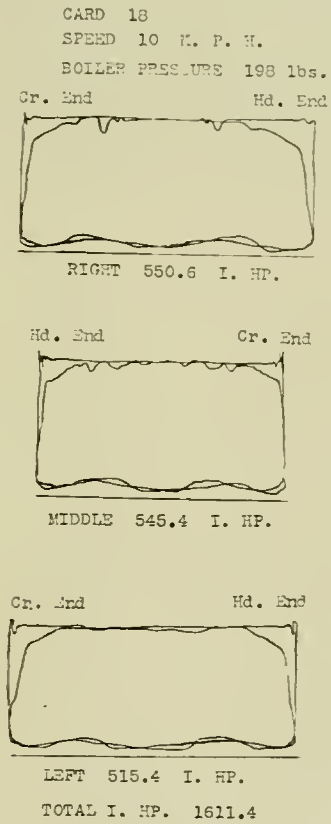
Between 1890 and 1900 the Erie and Wyoming Valley Railroad had several three cylinder simple locomotives built of the 4-4-0 and 2-6-0 types. These engines were in service between Dunmore and Honesdale. They demonstrated remarkable pulling power on grades and were noted for their steady riding. They were in service for several years, but difficulties with crank axles resulted in their being converted to the two cylinder type. Earlier than this, Wm. Webb had in service a number of three cylinder compounds on the London and Northwestern



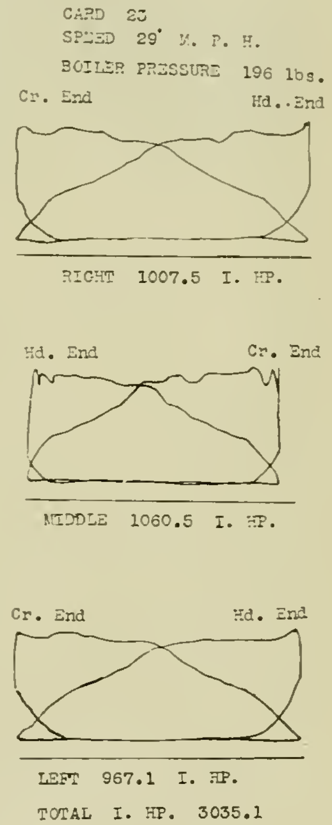
Indicator Card Taken on December 29



Indicator Card Taken on December 30



Low Speed, Long Stroke Indicator Card Taken on December 29



Indicator Card Taken December 29: Showing Max. HP.

Railways. These locomotives did excellent work for a long period. One engine of this type was tried out in this country. Mr. H. N. Gresley of the Great Northern Railway of England also introduced three cylinder locomotives on that road several years ago. These locomotives rank high as to design and workmanship, and it is reported that their performance has been, and still is, most satisfactory. Several years ago the Philadelphia and Reading road also built three cylinder simple ten wheel and Atlantic type locomotives. These locomotives made some remarkable runs, but difficulties with the crank axles and inside valve motion also led to their conversion to the two cylinder type.

Experience with this arrangement of cylinders on the locomotive has, however, demonstrated the advantages inherent in the design, *i.e.*, more uniform torque; the possibility of lower factor of adhesion as compared with two cylinder engines; the ability to handle trains when once in motion at a shorter cut-off than the two cylinder type and better combustion conditions are also obtained, due to the more uniform blast from the exhaust. For a given weight on drivers, therefore, the three cylinder type gives more power, steadier pull, better economy in the use of steam and more economical combustion of the fuel.

In a two cylinder engine, the arrangement of the cranks is such that with 85 per cent cut-off, if the mean tractive effort be 40,000 lb., at one point in the revolution, the tractive effort will rise to 50,000 lb., and unless there is sufficient weight on the drivers the engine will slip. In the case of the three cylinder arrangement with the same cut-off and mean tractive effort, the increase will only be to 42,400 lb., requiring much less adhesive weight to prevent slipping than the corresponding two cylinder design.

It is thus seen that with the three cylinders we may readily get a very high starting torque uniformly applied, thus reducing the stress on the draft gears, and also, that with the train once in motion, it may be hauled with a much shorter cut-off. Roughly, with a train loaded up to the maximum starting capacity in each case, it may be hauled after starting at a 50 per cent cut-off with a two cylinder engine, and at a 35 per cent cut-off with a three cylinder engine, thus promoting the economical use of steam.

Two cylinder simple locomotives in this country have now been built of a size where piston thrusts are exceptionally high; cylinder sizes being as great as 31 in. and boiler pressure running from 200 to 250 lb. Realizing the limitations of the two cylinder engine, the American Locomotive Company in 1922 converted a two cylinder 4-8-2 fast freight locomotive into a locomotive of the three cylinder type. This locomotive was one of a number built for the New York Central, originally with 28 in. x 28 in. cylinders. In converting, three cylinders 25 in. x 28 in. were used. In addition to this, the locomotive was fitted with a Booster, Type E superheater, Elesco feed water heater and an Elvin mechanical stoker. The engine was placed in freight service on the Mohawk Division of the New York Central and the results obtained were eminently satisfactory. The increase in weight on drivers as compared with the two cylinder engine was very small, and the additional hauling capacity warranted a considerable increase in the tonnage rating.

The satisfactory working out of this design led the builders to develop and build a complete new locomotive of this type. The wheel arrangement was kept the same as in the New York Central locomotive, as was also the size of cylinders and diameter of driving wheels. Type A superheater was used, combustion chamber and Elvin Stoker applied, and the main rods instead of being coupled all to the second pair of driving wheels were coupled inside to the second axle and outside to the third.

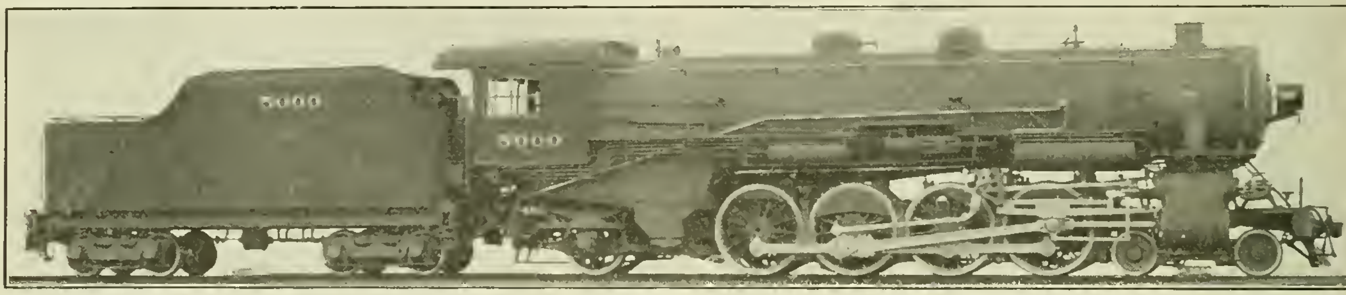
This engine was turned out of Brooks Works of the American Locomotive Company in October, 1923. It was immediately placed in service on the Buffalo Division of the Lehigh Valley Railroad, and for several weeks engaged in hauling heavy freight trains over that division. The locomotives used in this service had been of the Mikado type with a tractive force of about 63,000 lb. This three cylinder engine had a tractive force of 64,700 lb. The ruling grade on this division is 21 feet to the mile, or 4 per cent, and the tonnage rating of the Mikado engine was 3,000. This same tonnage was given to the three cylinder locomotive. It was handled with ease, and gradually increased until it reached a little over 4,500 tons. This engine handled a 4,500 ton train over the division 94 miles long, in four hours and thirty minutes running time. The performance of the locomotive on this division fully demonstrated the advantages claimed and the Railroad Company decided to conduct an indicator test which would also include accurate coal and water readings.

The locomotive was equipped for test purposes at the East Buffalo shops of the Lehigh Valley Railroad as follows:

Gauge glasses were applied to the corners of the tank to measure the water, and the tank calibrated by weighing out the water in a barrel mounted on platform scales. A drop bottom coal box was applied to tender for measuring the coal. Capacity of the box was checked by repeated fillings and weighings of the dumped contents, the same grade of coal as was used on the trips being used. Thermometers were applied to the left steam pipe close to the steam chest and to the exhaust passage. Steam gauges were applied to the saturated and superheated sides of the header, and a recording steam-gauge connected to the boiler in such a position that it could be read from the indicator box. A speed recorder was applied in the cab. Indicators were applied to all cylinders, and a revolution counter used for checking the speed.

Preliminary runs were made between Buffalo and Manchester from December 20th to 23rd, for the purpose of adjusting the instruments and drilling the crew, and on the 29th and 30th a successful round trip was made, upon which the figures in the report are based.

The test of the 29th was made from Tifft Farm to Caledonia, where it was terminated on account of setting out a car for a hot box, thus eliminating any figured adjustments of the results for shifting delays, etc.



Three Cylinder Mountain Type Locomotive in Service on the Lehigh Valley Railroad—Built by the American Locomotive Company

The test of the 30th was run from Manchester to Depew, where the train was set off for the Tonawanda connection. This trip includes the long drift of 13 miles from mile post 425 to Depew and no deductions from the fuel and water consumed are made for this drift, all fuel and water from Manchester to Depew being credited to the actual working time of the engine, or time when the throttle was open.

The principal dimensions and proportions of the engine is given in one of the tables, and a summary of the test data and results of the two test runs is given in the other.

Particular attention is directed to the coal per indicated horse power hour on the run of the 30th, where the average cut-off was about 53 per cent. This is 2.56 lb. per indicated horse-power-hour, no deduction having been made for the coal used to operate the stoker and air pump, nor for loss at the pops.

The amount of saturated steam charged to the stoker and air pump was purposely kept at a conservative figure. Under the conditions of the test its determination depended upon estimation only.

Tonnage Ratiogs Compared

No. of Cyls.	Type	R. R. Class	Booster	Tractive Power	Tonnage Rate
2	2-8-2	N-4	None	59,000	3,000
2	2-8-2	N-4	With	69,000	3,500
2	2-8-2	N-5	None	63,000	3,250
2	2-8-2	N-5	With	73,000	3,750
2	2-10-2	R-1	None	72,600	3,500
3	4-8-2	S-1	None	64,700	4,500

Performance Compared

R. R. Class	N-5	R-1	S-1
Type	2-8-2	2-10-2	4-8-2
No. of cylinders	2	2	3
Diam. and stroke	27x32	29x32	25x28
Diam. of drivers	63"	63"	69"
Boiler pressure	200 lb.	200 lb.	200 lb.
Weight on drivers	235,500	289,000	246,500
Weight, total	318,000	370,000	369,000
Tractive power	63,000	72,600	64,700
Tonnage	3,000	3,500	4,000
Running time	5 hr. 30 min.	6 hrs.	4 hrs. 30 min.
Distance, miles	94	94	94
Time in minutes / Ton-miles	.00117	.00106	.000718

We give below a tabulated comparison of the No. 5000 with the Mikado and Santa Fe type engines operating on the Buffalo Division.

No dynamometer car was used during the tests; therefore, the starting characteristics of the locomotive are largely a matter of personal opinion. It was readily conceded, however by all observers, that the engine was exceptionally smart in starting, yet the start was so smooth.

TABLE OF DIMENSIONS, WEIGHTS AND PROPORTIONS OF LEHIGH VALLEY LOCOMOTIVE No. 5000

Builder	American Loco. Co
Type of locomotive	4-8-2
Service	Freight
Cylinders, number, diameter and stroke	3 25 in. by 28 in.
Valve gear, type	Walschaert
Weights in working order:	
On drivers	246,500 lb.
On front truck	66,000 lb.
On trailing truck	56,500 lb.
Total engine	369,000 lb.
Tender	201,000 lb.
Wheel bases:	
Driving	18 ft.
Rigid	18 ft
Total engine	41 ft. 2 in.
Total engine and tender	77 ft. 8 in.
Driving wheels, diameter outside tires	69 in.
Boiler	
Type	Conical
Steam pressure	200 lb.
Fuel	Bitu. coal
Diameter, first ring, inside	82½ in.
Firebox, length and width	126⅛ in. by 96¼ in.
Combustion chamber length	52 in.
Tubes, number and diameter	230—2¼ in.
Flues, number and diameter	50—5½ in.
Length over tube sheets	21 ft.
Internal area through tubes, and flues	10 sq. ft.
Grate area	84.3 sq. ft.
Heating surfaces:	
Firebox, comb. chamber and arch tubes	312 sq. ft.
Tubes	2,832 sq. ft.
Flues	1,505 sq. ft.
Total evaporative	4,729 sq. ft.
Superheating	1,249 sq. ft.
Comb. evaporative and superheating	978 sq. ft.
Special equipment:	
Brick arch	Security
Superheater	Type A
Stoker	Elvin
General data estimated:	
Rated tractive force, 85 per cent	64,700 lb.
Cylinder horsepower (Cole)	3,378
Speed at 1,000 ft. piston speed	44.0 m.p.h.
Weight proportions:	
Weight on drivers ÷ total weight engine, per cent	66.9
Weight on drivers ÷ tractive force	3.81
Total weight engine ÷ cylinder hp	109.2 lb.
Boiler proportions:	
Comb. heat. surface ÷ cylinder hp	1.74
Tractive force ÷ comb. heat. surface	10.83
Tractive force × dia. drivers ÷ comb. heat. surface	749
Cylinder hp. ÷ grate area	40.1
Firebox heat. surface ÷ grate area	4.65
Firebox heat. surface, per cent of evap. heat. surface	8.29
Superheat. surface, per cent of evap. heat. surface	26.42

The riding qualities of the locomotive are really remarkable for smoothness and freedom from lurching and vibration at high speeds. This shows very good balance and proportioning of the spring system, as well as counter-balancing in the driving wheels.

After the tests were completed this locomotive was transferred to the Seneca Div. East and Wyoming, Div., operating between Sayre and Lehighton, a distance of 145 M. via the mountain cut-off. The ruling grade on this division eastward is 61½ feet to the mile, and westward a maximum of about 69 feet to the mile. The purpose of this transfer was to find out if the locomotive could satisfactorily handle milk trains weighing approximately 1200 tons, which had been handled previously by Pacific type locomotives double-headed. The combined tractive power of the two engines going east was approximately 90,000 lb., and going west approximately 97,000 lb. Engine 5000 was given a trial trip, the weight of the train being a little over 1,300 tons. It had no difficulty in handling this train over the mountain alone and making schedule time. Since this trial trip it has been regularly used in milk train services and has had no help over the mountain at any time. The train, in some cases, was as high as 1,550 tons in weight. In this service speeds of over 60 miles an hour on level track have been frequently attained.

Below is a comparison of the performance of this engine with the Pacific type engines previously used to handle the Milk Train. Eastbound, a K 5½ engine was in the lead, and a K 2½ engine was used as a helper from Coxton to Gracedale.

SUMMARY OF ROAD TESTS OF LEHIGH VALLEY LOCOMOTIVE No. 5000

Date of test	Dec. 29	Dec. 30	Average
From	Tifft Farm	Manchester	
To	Caledonia	Depew	
Length of run, miles	59.4	77.4	68.4
Working distance, miles	56.4	62.4	59.4
Drifting distance, miles	3.0	15.0	9.0
Time, actual, start to stop, minutes	198	246	222
Time, delays, minutes	9	24	16
Time, running, minutes	189	222	207
Time, drifting, minutes	17	32	24
Number of stops	1	2	1.5
Number of cars in train, including caboose	94	64	79
Gross weight of train, excl. of locomotives	4,619*	3,929*	4,274*
100 ton-miles, based on distance run	2,744	3,041	2,892
Average speed while working, m.p.h.	19.68	19.70	19.69
Average speed while in motion, m.p.h.	18.87	20.92	19.89
Average temp. of feedwater in tank	40.2†	40.0†	40.1†
Average temp. of steam in branch pipe	615.5†	623.0†	619.3†
Average boiler pressure, lb.	185.6	194.1	189.9
Water from tank, lb.	131,840	138,550	135,195
Water lost at inj. overflow (est.), lb.	20	20	20
Water to auxiliaries, lb.	3,720	4,433	4,076
Water lost through pops, lb.	564	1,380	972
Water to cylinders, lb.	127,536	132,717	130,126
Water apparently evaporated per pound of coal as fired	7.288	7.658	7.473
Water app. evap. per hour, working time	45,984	43,746	44,865
Water to superheater per hour, per cent of total	96.75	95.80	96.28
Water per i.h.p. per hour, incl. auxiliaries, lb.	21.09	19.63	20.36
Water per i.h.p. per hour, less auxiliaries, lb.	21.09	19.63	20.36
Water per 100 ton-miles	48.04	45.55	46.80
Factor of evaporation combined (B.t.u. in steam total divided by 970.4 x total water evaporated)	1.353	1.355	1.354
Coal as fired per hour, working time, lb.	6,314	5,713	6,012
Coal as fired per sq. ft. of grate per hour, lb.	74.85	67.77	71.31
Coal as fired per 100 ton-miles	6.59	5.95	6.27
Coal as fired per i.h.p. hour, incl. auxiliaries, lb.	2.89	2.56	2.72
Coal as fired per i.h.p. hour less auxiliaries, lb.	2.81	2.47	2.64
Efficiency, combined, total B.t.u. in fuel, divided by 100	75.95	79.21	77.58
Average indicated hp. of locomotive	2,180	2,228	2,204
Average cut-off of locomotive, per cent of stroke	63.8	52.4	58.1
Maximum indicated hp.	3,035	2,896	2,966
At a speed of, miles per hour	29	46	37.5
Average gage pressure at steam chest	174.0	176.0	175.0

*Tons.
†Deg. F.

Westbound, a K 5½ engine handled the train, another K 5½ being used as a helper from Lehighton to Gracedale. The 5000 handled this same train without assistance

Comparison of Engines Used on This Train

R. R. Class	K 2½	K 5½	S-1
No. of cylinders	2	2	3
Diam. and stroke	25x28	27x28	25x28
Diam. of drivers	77"	73"	69"
Boiler pressure	215 lb.	205 lb.	200 lb
Weight on drivers	161,940 lb	204,560 lb.	246,500 lb.
Weight, total	262,160 lb.	311,900 lb.	369,000 lb.
Tractive power	41,500 lb.	48,700 lb.	64,700 lb.

Comparison of the Operation of the Milk Train

			With Engine No. 5000	
Direction	East	West	East	West
Ruling grade, ft. per mile	61½	69	61½	69
Average cars in train	19 loads 1 caboose	38 empty 2 cabooses	19 loads 1 caboose	38 empty 2 cabooses
Lead engine, class	K 5½	K 5½	S-1	S-1
Lead engine tractive power	48,720	48,720	64,700	64,700
Helper engine, class	K 2½	K 5½	None	None
Helper tractive power	41,530	48,720	.....	....
Total tractive power	90,250	97,440	64,700	64,700
Total weight of engines and tenders	574,000	623,800	570,000	570,000

in either direction, but dropped a little time on the hill in comparison with the two-engine operation. The schedule over the Division, however, is usually maintained without difficulty by the three cylinder engine.

The Railway Fuel Problem

By W. E. Symons

Conservation of fuel in all cases involves questions of combustion and this in turn necessitates consideration of different systems or methods best adopted to give desired results. In stationary and marine practice many forms of furnaces and methods of securing proper combustion of fuel are employed, while in locomotive practice this is fairly well defined, varying of course with size of engine, kind of fuel used, etc.

Artificial Draft

Many of our large stationary and marine plants operate by natural draft, but locomotives all are operated by artificial draft.

There are two kinds of artificial draft:

Blower or forced draft, and vacuum or induced draft, and locomotives are operated by the latter or induced draft method. Induced draft in the firebox is caused by the action of exhaust steam from the cylinders through nozzle tip and stack, thus causing a vacuum in the front end and tubes to firebox.

The force of this exhaust steam must of necessity be opposed at its source by the pistons and is therefore negative or back pressure and is controlled in large degree by the size or area of the exhaust nozzle tip, and as nozzles are adjusted or reduced to make engines dependable against steam failures under maximum adverse conditions, it follows that they are below their potential efficiency at all times, with no means of adjustment to meet the fluctuating conditions of service.

Railway transportation and mechanical officers and enginemen alike, detest the terms, "Engines don't Steam," "Engine failed on account no steam," etc., therefore there is sufficient pressure, permanently put on the pistons, to insure against any such complaint, although in most cases, as above stated, the engine is permanently handicapped to provide a remedy against an intermittent ailment or condition; and it is this feature which is open to severest criticism as it is unsound from an engineering standpoint, is unmechanical, is uneconomical to the paint of willful waste, and cannot be defended by those who by act of omission or commission are responsible for its continued existence in locomotive design, maintenance and operation.

Just what amount of back pressure should be allowed or provided for in each case cannot be accurately determined in advance, but this is no reason why means should not be provided for meeting the varying conditions in actual road service.

Back Pressure on Pistons

The following tabulation shows the exhaust pressure in pounds and the back pressure on pistons in horse power shown by indicator cards taken from 7 passenger and 11 freight engines on one of the large trunk lines.

A careful study of this table will bring out much interesting information, and serve to spur those interested in operation economies to "taking stock as it were" with a view of putting their own house in order.

TABULATED DISPLAY SHOWING DIMENSIONS, STEAM PRESSURE, EXHAUST PRESSURE IN POUNDS, AND BACK PRESSURE IN HORSE POWER OF SEVEN PASSENGER AND ELEVEN FREIGHT ENGINES, ON ONE OF THE LEADING TRUNK LINE RAILWAYS*

EXHIBIT—A.

Type	Dimensions and Steam Pressure: Dimensions	Steam	Exhaust Pressure in Pounds: Maximum	Minimum	Average	Back Pressure in Horse Power: 20 M. p. h.	30 M. p. h.	40 M. p. h.	50 M. p. h.	Remarks
4-6-2	25x28x73	200	16	8.5	12.6	185	240	295	350	Oil S. H.
4-6-2	23½x28x73	210	22	9.5	11.7	175	230	285	340	Oil and S. H.
4-6-2	17x28x28x73	220	19.5	6.5	11.4	140	290	440	590	Bal. Com. Oil, no S. H.
4-6-2	25x28x73	200	13.5	7	10	130	200	270	340	Coal and S. H.
4-6-2	22½x28x79	220	21	10	16.2	155	250	345	...	Coal no S. H.
4-4-2	15x25x26x79	220	14.5	7	9.2	75	155	235	315	Coal no S. H.
4-4-2	15x25x26x73	220	13.5	8	10.2	115	185	255	325	Oil and S H.
Average 7 Pass. Eng's.	....	...	17.1	8	12	139	221	304	376	

FREIGHT ENGINES

Type	Dimensions and Steam Pressure: Dimensions	Steam	Exhaust Pressure in Pounds: Maximum	Minimum	Average	Back Pressure in Horse Power: 10 M. p. h.	15 M. p. h.	20 M. p. h.	25 M. p. h.	Remarks
2-10-2	19x32x32x57	225	17	5	10.8	130	280	430	580	Oil, Tandem
2-10-2	19x32x32x57	225	13	7	10.4	160	250	340	430	Coal, no S. H., Tandem
2-8-0	16x28x32x57	210	16	10.5	12.5	150	225	300	375	Tandem, Coal
2-8-0	24x32x57	180	15	5	11.2	65	130	195	260	Oil and S. H.
2-6-2	17½x29x28x69	225	10	4.5	7.3	65	105	145	185	Bal. Com. Coal
2-10-2	24x32x57	225	16.5	10.5	13.5	120	210	300	390	Oil and S. H.
2-6-2	17x28x28x69	220	16.5	7	11.7	130	170	210	250	Vauclain Com.
2-10-10-2	28x38x32x57	225	23	6	16.5	300	650	800	1.050	Oil and S. H.
2-8-8-2	23x37x32x57	200	22	8	14.4	235	490	745	1.000	Oil and S. H.
2-8-8-2	26x38x34x63	225	19	8	11.2	290	385	480	575	Oil and S. H.
2-6-6-2	24x38x28x69	220	16	6	21.1	170	310	450	590	Coal and S. H.
Average 11 Freight Eng's	....	...	16.7	7	12.7	164	291	399	516	

P. S.—It will be noted the back pressure in horse power on pistons of passenger engines is at 20, 30, 40 and 50 m. p. h., while for the freight engines the speeds are 10, 15, 20 and 25 m. p. h.

* From proceedings I. F. A., 1912.

In the absence of weight of train and gradient, it might not be fair to attempt a too close comparison or criticism, in the absence of these factors, however, it is plain that many of these engines were simply hobbled so they could neither run or pull a train in an economical manner, and were wasting enough fuel in any 60-day period, to more than pay for such improvement as would remedy the trouble.

Excessive Back Pressure on Pistons and Its Effect on Operating Economy

The following tabulation will give a good idea of what this constant excessive back pressure means when converted in to good *American Dollars* and as this is the yard stick by which railway operation and locomotive economy is measured it will be well for all students to study this carefully.

With excessive back pressure on pistons of 100 to 500 horse power, due to bushed, bridged or otherwise contracted nozzle opening, the loss in fuel, based on 4 lbs. of coal per horse power hour, and coal prices $3.00, $4.00 and $5.00 per ton would range from $3.00 to $40.00 per engine day of 5 to 8 hours, and on a basis of six (6) hours per day, the annual loss in fuel ranges from $1,314 to $10,950.

Nozzles are reduced to make engines dependable against steam failures under maximum adverse conditions, consequently are below their potential efficiency at all times, with no means of adjustment to meet fluctuating conditions of service. Assuming the average excessive back pressure on pistons due to contracted nozzle to be only 100 H.P. with coal at $4.00 per ton and 6 hour day, the possible saving per year on 200 engines would be $1,752 x 200=$350,400, which sum capitalized at 6 per cent would justify an expenditure of $5,840,000.00.

In the above calculations, dimensions of engines are disregarded, and no estimate has been made of the increased earning power of the engine due to elimination of constant excessive back pressure on pistons.

P. S. Horse power hours do not include time engine is drifting or standing but only actual hours working steam with open throttle.

From the foregoing it must be clear that the field is so broad and inviting that even a mild effort will yield big returns.

EXCESSIVE BACK PRESSURE ON PISTONS AND ITS EFFECT ON OPERATING ECONOMY

(*Tentative*)

EXHIBIT—B

Extra Fuel Required Due to Excessive Back Pressure on Pistons in 5-6-7 and 8 Hours

Back Pressure on Pistons in H.P. and lbs. Coal		Pounds Coal Per Horse Power in 5-6-7 and 8 Hours					Possible saving per day of 5, 6, 7 and 8 hours with coal at $3, $4 and $5 per ton				One year's saving based on 6 hour day
Back Pressure in H.P.	Lbs. Coal H.P.	5 Hours	6 Hours	7 Hours	8 Hours	Price per ton, coal	5 Hours	6 Hours	7 Hours	8 Hours	
100	4	2,000	2,400	2,800	3,200	$3.00	$3.00	$3.60	$4.20	$4.80	$1,314
						4.00	4.00	4.80	5.60	6.40	1,752
						5.00	5.00	6.00	7.00	8.00	2,190
200	4	4,000	4,800	5,600	6,400	3.00	6.00	7.20	8.40	9.60	2,628
						4.00	8.00	9.60	11.30	12.80	3,504
						5.00	10.00	12.00	14.00	16.00	4,380
300	4	6,000	7,200	8,200	9,600	3.00	9.00	10.80	12.30	12.30	3,942
						4.00	12.00	14.40	16.40	16.40	5,256
						5.00	15.00	18.00	20.50	24.00	6,570
400	4	8,000	9,600	11,400	12,800	3.00	12.00	14.40	17.10	19.20	5,256
						4.00	16.00	19.20	22.80	25.60	7,008
						5.00	20.00	24.00	28.50	32.00	8,760
500	4	10,000	12,000	14,000	16,000	3.00	15.00	18.00	21.00	24.00	6,570
						4.00	20.00	24.00	28.00	32.00	8,760
						5.00	25.00	30.00	35.00	40.00	10,950

A Boomerang

"If the railroads were corporations operated under the conditions of strictly private business, their success or failure would not be a matter of deep public concern.

"But the railroads are not in this sense private enterprises—they are the life of the country and on their progress and proper development the prosperity of each and every American depends.

"Hence, to cripple them through legislation is not merely unethical—it is calamitous and the penalty will be inflicted upon the people themselves."—*E. M. Herr, President, Westinghouse Electric and Manufacturing Company.*

Railway Wages in 1916 and in 1923

The average hourly wage of railway employes at the end of 1923 was 120 per cent higher than in 1916. About 90 per cent of all employes are paid on an hourly basis. The average hourly wage in 1916 was 27-8 cents and in November, 1923, it was 61 cents. The average wage per day of all employes paid on a daily basis in 1916 was $3.04, and in November, 1923, it was $7.91, an increase of 160 per cent.

"This large increase was not due to increases in the compensation of officers, because in 1916 the average compensation of all division and general officers was $9.92 a day and in November, 1923, it was $17.10, an increase of only 72 per cent."

"The classification of employes of the Interstate Commerce Commission has been changed somewhat since 1916. Therefore, it is not possible to make exact comparisons between the wages paid then and now to each class of employes. The following statistics show the increases for some classes of employes for which accurate comparisons can be made:

Employes	Average wage per hour 1916	Average wage per hour Nov. 1923	Percentage Increase
Machinists	$.41	$.77	85
Blacksmiths	.393	.77	96
Road freight conductors	.50	.91	82
Road freight brakemen and flagmen	.335	.71	112
Road freight engineers and motormen	.61	1.10	80
Road freight firemen and helpers	.39	.88	126
Road passenger conductors	.71	1.14	61
Road passenger brakemen and flagmen	.40	.80	100
Road passenger engineers and motormen	.90	1.37	52
Road passenger firemen and helpers	.56	1.05	88

"The average earnings of all employes in the year 1916 were $892.00, or $74.33 a month. In the twelve months ended with November, 1923, they were $1,626.00, or $135.55, an increase of only 82 per cent. But this apparent discrepancy between the earnings per day and per hour, on the one hand, and the earnings per month, on the other hand, is entirely due to the fact that the average number of hours worked per day and per month by a great majority of the employes has been substantially reduced.

"The employes sought these reductions of hours. Presumably, they are of as much value to them as a corresponding increase in wages would have been.

"On the other hand, the reductions in hours of work have increased the amount of wages the railways must pay by making it necessary for them to employ more men. In consequence, for every one thousand tons the railways hauled one mile in 1916 they paid out $3.10 in wages, while for every one thousand tons they hauled one mile in 1923 they paid out $6.10 in wages, or almost twice as much."

The Compound Locomotive on the Baltimore and Ohio Railroad

By John E. Muhlfeld

The article by Mr. Geo. L. Fowler on "The Pennsylvania Railroad and the Modern Locomotive," in the March, 1924, issue of Railway and Locomotive Engineering, has been of considerable interest to me, especially that portion relating to the "Compound Locomotive," reading as follows:

"But the compound locomotive, as introduced in this country was a competitive enterprise. Each manufacturer had his own design to exploit and used it as a means of making sales. But immediately upon the consolidation of a number of the builders, the compound locomotive exploitation ceased, and they gradually went out of existence except in special cases, thus finally corroborating, by practice, the position that has been assumed on the Pennsylvania.

"At times the pressure to adopt the compound locomotive was very great and a single case in point will serve to illustrate the situation. Mr. F. D. Casanave was superintendent of motive power at Altoona during the controversy and was offered, and accepted the position of superintendent of motive power of the Baltimore & Ohio. A few weeks before he left the Pennsylvania he sent some members of his staff to the Baltimore & Ohio to inquire into the service rendered by the compound locomotives, because of the pressure that was being brought to bear to purchase some for the Pennsylvania. They came back with very favorable reports. They had not witnessed any performance themselves, but talked with the men who were handling them, and it looked as though the Altoona officials were holding back too firmly. But Mr. Casanave had not been on the Baltimore & Ohio a week before he telegraphed Mr. Ely not to take any action on the report of those men, until he (Mr. Ely) should hear from him (Mr. Casanave). He said that they had come away with a very wrong impression, and it shows how difficult it is to go to any road that is not investigating a thing critically and getting information on which action can be taken with reliance."

As successor to Mr. Casenave as General Superintendent of Motive Power of the Baltimore & Ohio, I fell heir to the work that had been commenced of converting all compound to simple cylinder type locomotives.

My subsequent study of the situation convinced me that these conversions should apply only to those Vauclain four-cylinder compound types which had been designed with the low pressure cylinders disposed above the high pressure cylinders with off-set crossheads due to the difference in distance between the high and the low pressure cylinder centers, and more particularly on account of the water of condensation from these low pressure cylinders gravitating into the high pressure cylinders, and causing many cylinder failures. In addition the difficulty to maintain high pressure cylinder packing rings in a tight condition caused excessive pressures in the low pressure cylinders and consequential broken frames. These troubles, however, did not obtain to any great extent in the Vauclain four-cylinder compounds, with the high pressure located above the low pressure cylinders where the cylinder centers were equally spaced and the crossheads, side rods and other parts were not off-set. Neither did they obtain in the Rhode Island two-cylinder compound locomotives.

After a careful analysis of the situation we continued the instructions which Mr. Casanave had issued, so far as the simpling of the Vauclain compounds with the low pressure cylinders located above the high pressure cylinders were concerned, but discontinued the simpling of the more favorable types of Vauclain four-cylinder and of the Richmond Cross-Compounds, for the reason that with proper maintenance they could be satisfactorily operated without going to unjustified capital and maintenance expenditures. Furthermore, they could start and handle the same tonnage trains easier and with from 15 to 20 per cent less fuel consumption and less manual labor on the part of the firemen. The records of the performance of the more favorable types of Vauclain compound and of the Rhode Island cross-compound locomotives on the Baltimore & Ohio will confirm this, even though that company has converted 268 Vauclain four-cylinder, 38 Rhode Island two-cylinder and 1 Pittsburg Tandem cylinder, or a total of 307 compounds put into use between 1889 and 1901 into simple cylinder locomotives.

It will be remembered that Mr. Cananave supervised various locomotive tests made on the Altoona Testing Plant when it was installed at the St. Louis Exposition. One of the locomotives tested was an imported "DeGlehn Balanced Compound." From the reports, this DeGlehn Compound showed great economies as compared with domestic locomotives operating under like conditions. Furthermore, there is no getting around the fact that the Mallet and other locomotives of the cross-compound types, and even the Vauclain Four-Cylinder Compounds with their inherent design deficiencies, would produce a saving of from 15 to 20 per cent in the actual coal as fired per unit of work performed at the drawbar. This was demonstrated in more ways than one on the Baltimore & Ohio, where no saturated steam locomotives could ever produce the fuel performance, month in and month out, of the Rhode Island Two-Cylinder and the Mallet and Vauclain Four-Cylinder Compounds. In the case of the latter, after they were simpled, when we were "hard put" for engineers and firemen at Cumberland, it was always possible to get a fireman to go out on a Vauclain Four-Cylinder Compound after he would refuse to double back on the same class of locomotive which had been simpled. This, more than anything else, demonstrated to me the greater steaming capacity and the lesser coal consumption of the compound type of locomotive. Also, these Vauclain Four-Cylinder and Rhode Island Cross-Compound locomotives could always start and accelerate a train out of a yard or passing track much more quickly than a converted single expansion locomotive.

Disregarding the question of indifferent design of the Baldwin Four-Cylinder and the Rhode Island and other two-cylinder compounds which were put into use during the 1889-1901 period, I am firmly convinced that had the use of the superheater been inaugurated in this country prior to the advent of the compound locomotive, the latter would still be in use, as the troubles due to excessive condensation in the low pressure cylinders would the not have occurred.

As related in your article, the Pennsylvania people have never extended the use of the Compound locomotive, although they have recently constructed many hundreds of a 2-10-0 type of freight locomotive, which they term their "50 per cent cut-off engine," i.e., they have a special device for starting the locomotive, but after starting this cuts out and the locomotive can then be worked at not to exceed 50 per cent cut-off as compared with the average locomotive, which can at any time, dependent upon speed, be operated from a minimum to about 89 per cent cut-off. It is evident from their decision in this regard that the Pennsylvania engineers realize the benefit of compounding, as in these locomotives the 50 per cnt cut-off schme pratically provides for a double expansion in each cylinder and should approximate the economy of a 2 to 1 or a 2¼ to 1 ratio compound locomotive, but without the advantages of cross-compounding.

The Railways and the State*

By Sir Henry Thornton, Chairman and President, Canadian National Railways

In these days every country appears to have a railway problem. In some states the problem is one of reconstruction and reorganization necessitated by the ravages of the war; elsewhere it may be dissatisfaction with private enterprise, or again an effort in the direction of reduced freight rates; but whatever the movement may be it seems to be an expression of unrest and dissatisfaction with the part the transport system is playing in the life and development of the community. Various solutions have been suggested, covering the entire scale of human endeavor, without apparently effecting a permanent remedy.

We who have lived on this side of the Atlantic and enjoyed the untold blessings of tranquility and freedom from warfare, can hardly appreciate the necessity for that eternal vigilance which elsewhere has been the only price at which existence could be purchased. However much the European may deplore the excursions of Mars which have afflicted his continent from time immemorial, his point of view with respect to war, by hereditary alone, is fundamentally different from our own feelings on the subject, and he views the intervention of the state with respect to his railways as a necessary effort to strengthen the military machine. It is interesting to observe that the state ownership of railways has not thus far invaded the United Kingdom, probably for the reason that the United Kingdom itself has never been invaded or pillaged by the enemy since the days of William the Conquerer in the eleventh century. In making this statement I ignore the air raids of the Germans during the late war, as the damage inflicted was relatively negligible.

On the North American Continent, with the exception of the Canadian National Railway System, there has been a general commitment to the principle of privately-owned railways. This has come about, first, because in a new country the poverty of the government must necessarily leave much to private initiative, and secondly, freedom from attack and invasion relieved the state of the acquisition of the transport system as a military adjunct. But, as intimated at the outset of my remarks, there seems to be sufficient complaint, as well as threats, to keep these private enterprises in a state of defense, and to some degree a state of turmoil.

I have no desire or intention to embark upon an argument for or against state ownership of railways, but I think I may from a somewhat varied experience in the railway profession point out some of the essential factors of the problem which may be employed as a yardstick to measure your position, and the groundwork for our subsequent discussion may be summarized as follows:

*An address before the American Railway Engineering Association March, 1924.

(1) An adequate means, at reasonable cost, for the conveyance of persons and goods from one place to another within the frontiers of any country, and the performance of that same function with respect to international traffic, is essential for the advancement of civilization and the development of industrial life.

(2) Transportation has a greater effect upon, and is more intimately connected with, the daily life of the individual and the welfare of the nation than almost any other form of commercial activity.

(3) For these reasons transportation, of which the railway is the most efficient expression, has from all time been regarded as an important function of the state, or, if delegated to private enterprise, the state has exercised a constantly increasing scrutiny and regulation in the interests of its citizens.

Any lapses of sufficient duration and importance are likely to prove a discontent which finds expression in a demand for government ownership.

Arguments for State Ownership

Those who favor the government ownership of railways generally advance something like the following arguments:

First—That railways play such an important part in the life of the community that they cannot be safely entrusted to private ownership, lest discrimination, injustice and various irregularities develop.

Second—That under state ownership rates and fares can be fixed upon that scale which will best promote development and progress.

Third—That, broadly speaking, a higher degree of justice will be accorded to communities and the public in general than under private ownership.

Arguments for Private Ownership

Those who favor private ownership and operation of railways generally contend:

First—That state-owned and operated railways are inefficient, unprogressive and expensive, largely because of the impossibility of divorcing entirely the railway administration from the field of politics and the feeling that officers and employes working for the state have less reason for initiative and industry than those who are employed by private corporations.

Second—That in a democracy, the more that is left to private initiative, the better.

Third—That state ownership is a form of paternalism treading closely upon the heels of socialism.

As a matter of fact, beyond the general and broad statement that transportation has such a vital effect upon the community that it should properly be in the hands of the state, and the argument that the interjection of politics in any railway system is bound to produce disaster, there is not much to be added either for or against government ownership, and the problem becomes entirely a matter of expediency in individual states. What may be necessary or desirable in one country may be quite the reverse in another, and some formula must be sought which will give expression to this principle.

Essentials for Private Ownership

There are three cardinal principles essential to the existence of any railway as a private enterprise:

(1) It must maintain solvency and meet its financial obligations.

(2) It must furnish adequate transportation at reasonable rates to the public.

(3) It must pay to its employes that wage, which, under reasonable conditions, will permit them to live in decency and comfort under sanitary conditions, and to educate and bring up their children as self-respecting members of society.

Let us elaborate a little these three principles.

Solvency, which is to say the ability to meet obligations, is the first factor in the existence of any institution. A railway which finds itself insolvent is not only placed in the hands of a receiver, but, being unable fully to perform its transportation obligations to the community, becomes a menace and a deterrent to progress and development. Therefore, obviously, solvency must be maintained.

A railway which though solvent, imposes rates and fares which throttle the industrial life of the community and produce discomfort among its citizens, cannot be permitted to pursue such a course without increasing protest and the probability of exciting state intervention.

If the wages paid and the working conditions imposed upon the employes are of such a character as to provoke strikes and continued interruptions of traffic, again, in the interests of the community, there must be some form of correction at the hands of the state.

A material departure from any of these three principles by privately owned railway systems will probably excite a demand for state ownership, and a departure from all three will in time inevitably produce that result. For example, in Canada a considerable proportion of our railway mileage was threatened with insolvency, and the government of that day took over those properties in the interest of the Dominion. There has been some contention as to whether this course was wise or not. In my opinion, for what it is worth, I think it would have been difficult to have pursued any other policy. At any rate, it was insolvency which brought into existence the Canadian National Railway System, and, quite apart from the merits of the argument, I know of no practicable way to dispose of that system without great loss to the Dominion, accompanied, perhaps by a considerable and detrimental restriction in service.

There is another factor which bears upon the problem of state ownership, which is social in character. The unprejudiced observer cannot fail to note an increasing spirit of discontent and dissatisfaction in the masses of the public in all countries with respect to the distribution of wealth. The world as a whole produces sufficient to preclude the existence of hunger and misery among the people of any community except, of course, when there may be occasional periods of famine, and in such cases the surplus production elsewhere should be sufficient to provide sustenance. But in all countries, states and cities there do exist in certain quarters misery, distress and hunger, and any system of distribution which permits the existence of such things is fundamentally inefficient if not actually wrong. It is an insufficient answer to say that suffering is the result of incompetence or a lack of industry and enterprise, or that the average individual receives what he deserves. Such arguments neither appease hunger nor clothe the naked, and the fact remains that for decades there has been a constantly increasing feeling on the part of the great body of the people that our system of distribution of wealth is wrong and should be changed. Increased taxation to the rich, income taxes, death duties —all of these things which find expression in the statutes of almost every country today—merely indicate the kind of evolution which is going on in the minds of the public, and, curiously enough, we accept today as reasonable what we regarded but yesterday as nothing short of confiscation.

What is the responsibility which rests upon those who have it within their power to influence the minds of men? It seems to me it is their responsibility to so administer the affairs in their charge as to permit the advancement of social life and the development of economic problems by evolution rather than by revolution, and, above all, to speed on the work of educating each oncoming generation; for, in a democracy, the government can possess no greater intelligence than that of the average intelligence of the electorate.

What bearing has this upon the state ownership of railways, and is it an important factor in the examination of that problem? It has this bearing: it produces in the minds of the great mass of the people the feeling that state ownership of railways is a step towards an improvement in that scheme of distribution with respect to which they complain, and it furnishes a fertile soil for the propagation of the theory of government-owned railways.

Conclusions

Any discussion, such as the one which is now being inflicted upon you, can only be worthwhile if it can be summarized into concise conclusions for the purpose of provoking intelligent and useful discussion. May I, therefore, recapitulate the conclusions which have already been somewhat elaborated:

(1) An adequate means of transportation at such rates and under such conditions as will promote industry and progress is essential to the well-being of any nation.

(2) There is an inherent conception that transportation is properly the function of the state, but, where it is delegated to private enterprise, the state is justified in maintaining such scrutiny and regulation as will prevent abuse.

(3) Under existing circumstances the advisability of state ownership of railways depends upon the conditions existing within the frontiers of each nation; but a departure from the three cardinal principles previously laid down will probably provoke government ownership.

(4) The undercurrent of dissatisfaction which exists to a considerable degree among the masses of most nations is a danger sign which should not be ignored by those who wish to retain in private hands those forms of industry which vitally affect the welfare of the community.

(5) State ownership is only practicable in the presence of an enlightened and intelligent population, and in the event of complete divorcement from influences other than those which have for their object the welfare of the community.

(6) The fate of our great railway undertakings will depend to a very large degree upon the sagacity, the justice and statesmanship of those who administer these properties during the present uncertain period, when the psychology of men is undergoing a rapid change and development throughout the civilized world.

The Locomotive Booster

The Effect of the Locomotive Booster on Operation and Its Efficiency As An Engine

By M. H. Roberts, Vice-Pres. Franklin Railway Supply Co., Inc.

The modern steam locomotive with its large boiler and firebox and its powerful reciprocating engine is an answer to the continual demand for more power; bigger locomotives to haul more tonnage and still larger locomotives to haul the tonnage faster. To provide these engines with steam requirements, large, heavy boilrs were necessary. This in turn called for big fireboxes. To support and carry a portion of this increased weight, the trailer axle and truck were introduced. This applies to both passenger and freight locomotives.

Starting Power Governed by Weight

Locomotive starting power is governed by the weight carried on the drivers. The trailer axle usually carries as much weight as one pair of driving wheels. On an Atlantic type or 4-4-2 locomotive, this weight would equal approximately for all intents and purposes 50 per cent of the total weight carried by the driving wheels; 33⅓ per cent on the 4-6-2; 25 per cent on the 2-8-2; and 20 per cent on the 2-10-2.

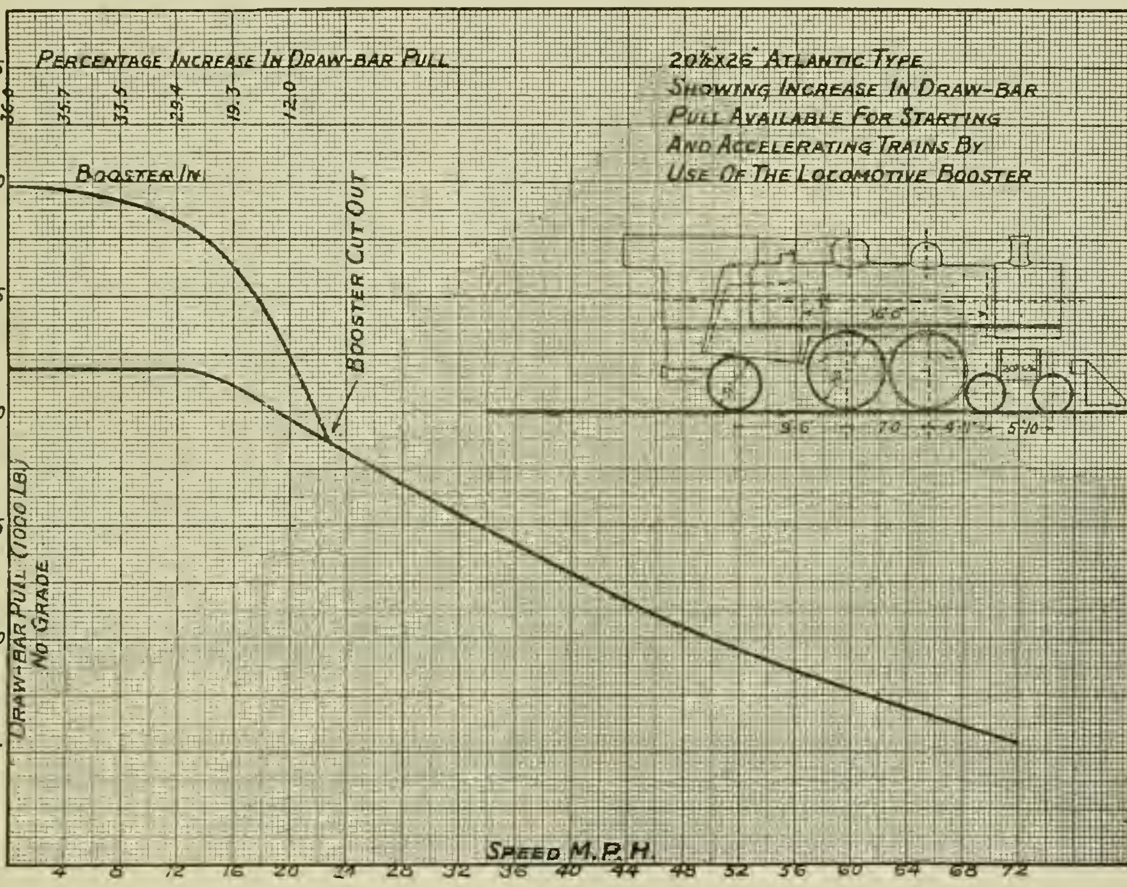


Chart No. 1

Here is idle weight of magnitude which could permit a certain amount of torque being applied to the trailer axle. Various ways and means have been devised to utilize this idle weight:

1—To make the trailer wheels into a pair of drivers by connecting them up with side rods to the other drivers. This meant that the trailer wheels would have to be increased in diameter to that of the drivers. Just as soon as this was done the firebox was interfered with and other complications came into play.

2—Another effort was to transfer the weight momentarily on to the driving wheels by some mechanical arrangement. This upset the inter-relating functions of the different units at the rear end.

3—Finally, the idea was conceived of developing means for transmitting torque to the trailer axle, thus converting it into a driver and increasing the starting power of the locomotive from 10 to 50 per cent, depending upon the type of locomotive.

In the application of the idea certain limitations and functions had to be considered, such as:

1—Minimum amount of changes in existing locomotives.

2—No disturbance in the relation between the firebox, trailer axle and diameter of trailing wheel.

3—Installation of the power unit so that it would deliver the torque to the trailer axle without, in any way, affecting the action of the rear end of the locomotive.

4—Additional power is desirable only at starting and low speeds, where the boiler can supply more steam than the main engine can utilize; hence, the power unit should normally be controlled by the engineer, but should be inoperative automatically after the locomotive has attained a pre-determined speed.

5—No interference with the functioning of the locomotive at high speeds.

With these conditions to meet, the inventor applied his idea in a practical form to an Atlantic type, or 4-4-2 locomotive. His arrangement took the form of a two-cylinder, 90° simple steam engine, transmitting its power to the trailing axle through an idler gear which could be engaged or disengaged at the will of the operator. The steam supply was taken directly from the locomotive boiler.

Results of Tests

Results of the first tests made on this locomotive are shown on chart No. 1. Here is plotted the draw-bar pull curve of the locomotive with and without the assistance of the power increasing device. The outstanding feature was the material increase in the starting power of the locomotive amounting to 36 per cent.

So satisfactory was the performance of this appliance on the Atlantic engine, that a second application was made to a Pacific type, or 4-6-2 locomotive. Results of the tests conducted with this locomotive are shown on chart No. 2, which again brings out the tremendous advantage of this device for starting and for low speed operation. From this chart, it will be seen that the starting power of the locomotive was increased 23 per cent.

Extended performance of these two locomotives equipped with the power-increasing device proved the desirability of such an arrangement.

At the present time, there are 1,200 of these Boosters in service on 35 railroads in the United States and Canada; one in England and applications are now being made on several South American roads. They are applied to many different classes and types of locomotives, both passenger and freight.

There follows a brief resumé of some of the results obtained by the application of the locomotive Booster:

The Booster in Passenger Service

1—Smoother starting and quicker acceleration which results in greater comfort of passengers and ability to maintain train schedules.

2—Assurance of sufficient power to start passenger trains under adverse conditions.

3—Increased tonnage in some cases, owing to the greater starting ability of the locomotive.

The Booster in Freight Service

1—Elimination of taking slack when starting freight trains resulting in reduced cost of equipment maintenance.

2—Virtual reduction in the ruling grade of a division.

3—Elimination, in many cases, of expensive helper service.

4—A material increase of tonnage in many cases.

5—Increase in ton miles per hour per locomotive over a division.

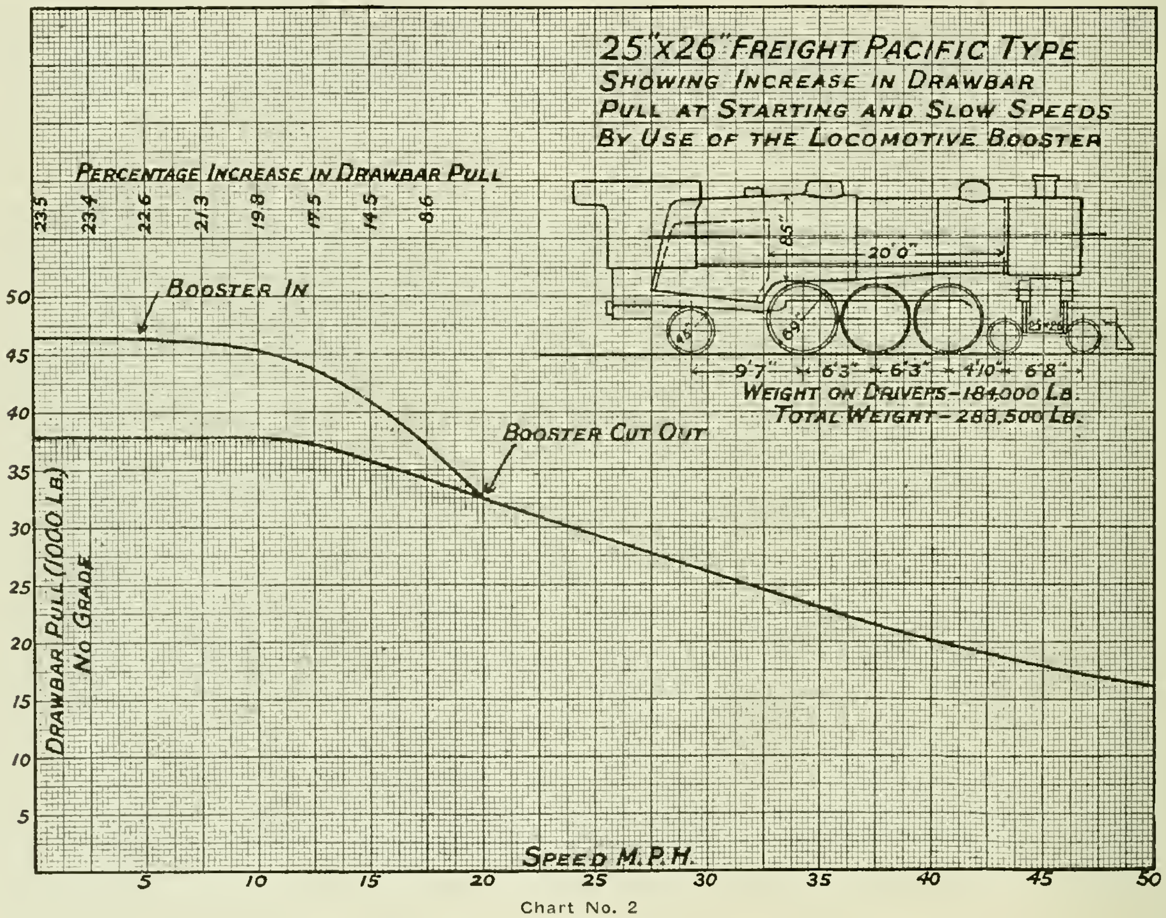


Chart No. 2

The Booster Increases Acceleration

To more fully comprehend the reasons for the above results, chart No. 3, which is a graphical representation of the results obtained from a locomotive in freight service, was prepared. This illustrates the accelerating possibilities of the Booster, and also shows the effect of the Booster in pulling a heavy train up a grade at a speed higher than the locomotive could attain alone.

While the acceleration due to the locomotive Booster is great, the difference between the steady speeds attained after the acceleration periods are over is even more remarkable in certain cases. For example, an inspection of chart No. 3 shows that on a grade of 0.5 per cent the steady train speed without the Booster is 6 miles per hour, while with the Booster in operation it is 16 miles per hour.

On chart No. 3, the draw-bar pull in thousands-of-pounds exerted by the locomotive or required to pull the train is plotted vertically and the speed of the train in miles per hour is plotted horizontally. The draw-bar pull required is based on a 2,500 ton freight train with cars averaging 40 tons each in weight. When the train is pulled up a grade, the resistence at any speed is evidently increased by an amount equal to the weight of train multiplied by the grade. In this case $2{,}500 \times 2{,}000 \times 0.001 = 5{,}000$ lbs. for each 0.1 per cent increase in grade.

The series of dotted curves in chart No. 3 shows the train resistance or the total draw-bar pull required to move the train at constant speed.

Starting on a level track it is evident that the locomotive, even without the Booster, can exert a draw-bar pull greater than the train resistance. The difference between 37,000 lbs. and 10,500 lbs. is available to accelerate the locomotive and train. Consequently, the speed of the train will increase, the train resistance increasing and the locomotive draw-bar pull decreasing until, finally, the draw-bar pull of the locomotive just equals the train resistance rather than between the locomotive draw-bar pull and the total force exerted by the locomotive.

Booster Acceleration on Grades

When on a grade, the increase in acceleration due to the Booster is greater than on the level. For example, with a grade of 0.3%, an inspection of chart No. 3 gives the increase in acceleration due to the Booster as:

$$\frac{47{,}000 - 37{,}000}{37{,}000 - 25{,}500} = 87\%$$

That is, without the Booster, assuming the weight of the locomotive and tender to be 400,000 lbs., the acceleration would be:

$$\frac{37{,}000 - 25{,}000 \times 32.2}{2{,}500 \times 2{,}000 + 400{,}000} = 0.069 \text{ ft. per second per second}$$

or 0.047 miles per hour per second, while with the Booster in operation the acceleration would be:

$$\frac{47{,}000 - 25{,}500 \times 32.2}{2{,}500 \times 2{,}000 + 400{,}000} = 0.128 \text{ ft. per second per second}$$

or 0.87 miles per hour per second.

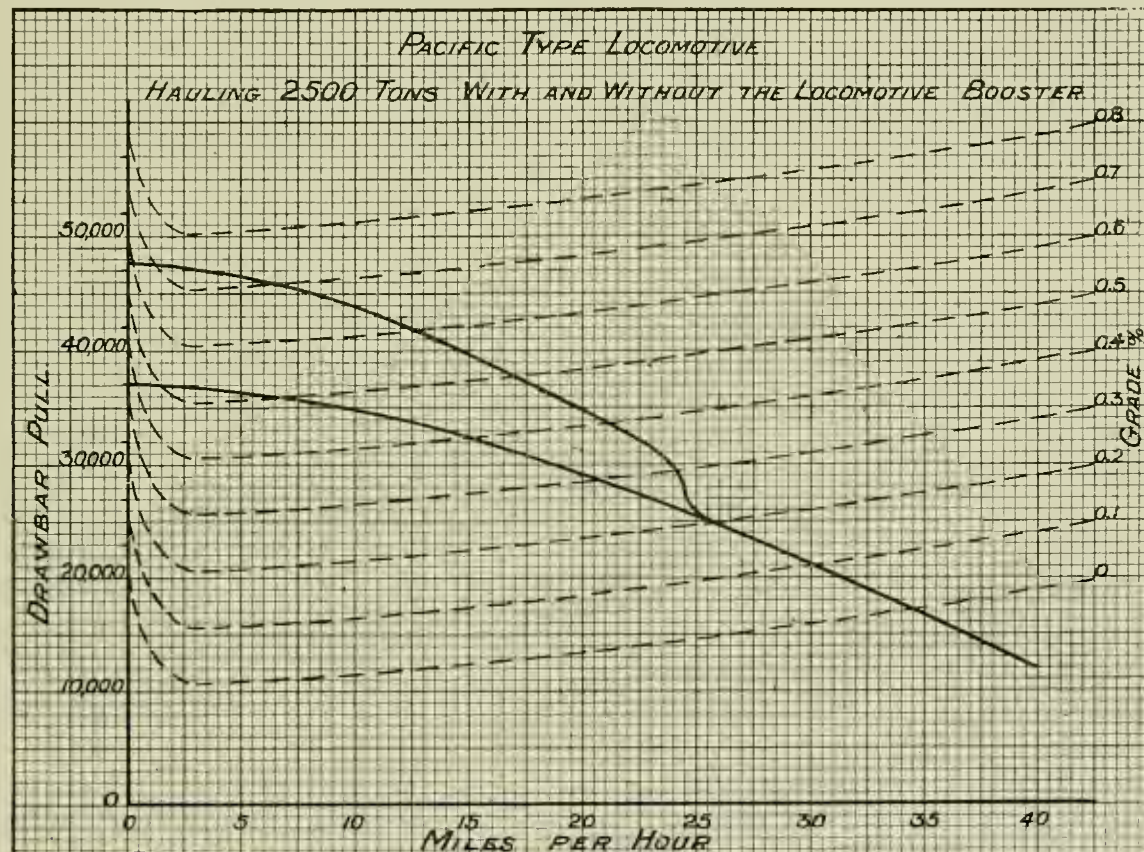


Chart No. 3

sistance. The accelerating period will then be over and the train will run at the constant speed of 34 miles per hour on level track. Incidentally, the increased acceleration due to the Booster at starting is greater than the ratio of the additional draw-bar pull of the Booster as compared with the draw-bar pull of the locomotive without the Booster. The true ratio would be:

$$\frac{47{,}000 - 37{,}000}{37{,}000} = 27\%$$

The accelerating force is, of course, the difference between the locomotive draw-bar pull and the train re-

On a 0.3 per cent grade, the train would attain a constant speed slightly above 20 miles per hour.

On a 0.4 per cent grade, it is evident that without the Booster the constant speed attained would be 14 miles per hour represented by the point on the chart where the train resistance curve crosses the curve of the draw-bar pull of the locomotive without the device. With it in operation, however, the steady speed would be nearly 21 miles per hour, represented by the point on the chart where the train resistance curve crosses the draw-bar pull curve with the Booster.

On a 0.5 per cent grade, the speed without the Booster would be about 6 miles per hour and with the Booster 16 miles per hour.

On a 0.6 per cent grade, the train would stall without the Booster, while with the Booster, a speed of 12.5 miles per hour could be steadily maintained.

The greatest advantage of the Booster as shown by these curves is in enabling the locomotive to make a grade of over 0.7 per cent, while without the Booster this weight of train would stall the locomotive on a grade slightly more than 0.5 per cent.

Even with a grade of 0.5 per cent, however, the Booster offers the advantage of enabling the train to make a speed of 16 miles per hour, instead of only 6 miles per hour, thus saving:

$$\frac{16-6}{16} = 62.5\%$$

of the running time on the grade.

With a grade of any appreciable length, this saving of running time is an important item, particularly near congested stations. It is also responsible for a saving in steam and fuel.

The Booster and Limited Full Gear Cut Off

In the present design of locomotives, the size of cylinders is determined by two factors:

(a) The relation of power at full gear cut-off to the adhesive weight and

(b) The capacity of the boiler to furnish sufficient steam.

Since the advent of the Booster, locomotive designers may now, deliberately, over-cylinder the locomotive, thereby obtaining at the higher speeds a substantial increase in draw-bar pull by operating at the shorter cut-off with increased steam economy; also to prevent slipping at start which would ordinarily occur with full gear cut-off, reducing the maximum cut-off to such an extent, in the form of limited full gear cut-off, to give a proper relation of power to adhesive weight. In addition, this results in a smoother torque or rotative effort curve. The Booster, with its smooth torque, combined with the power of the locomotive, enables the locomotive to have the proper starting power and with a better factor of adhesion than is generally used.

Chart No. 4 shows graphically this advance in the art. The tractive effort curve, marked "A," is a typical curve of the conventional type of Mikado locomotive having a starting power of 60,000 lbs. The factor of adhesion at start is just about enough to eliminate slipping. This curve shows the natural characteristics which obtain with increased speed up to 35 miles per hour. Inter-relating the Booster with limited full gear cut-off into a Mikado engine of the new design, consuming approximately the same steam consumption, results in the tractive curve "B."

At 20 miles per hour, the power of this new engine is 5.6 per cent over the previous engine and if this engine is operated on full gear cut-off at start, it would deliver close to 70,000 lbs. tractive effort and, having the same weight on drivers, would ordinarily upset the locomotive equation in that it would be a very slippery engine and a great deal of trouble would be experienced.

By the application of the Booster with limited full gear cut-off, one can readily see what a beautiful starting engine this is and, it will be noted, the starting power is higher than could possibly be attained, if the full gear cut-off was carried, as mentioned above, and if the engine did not slip.

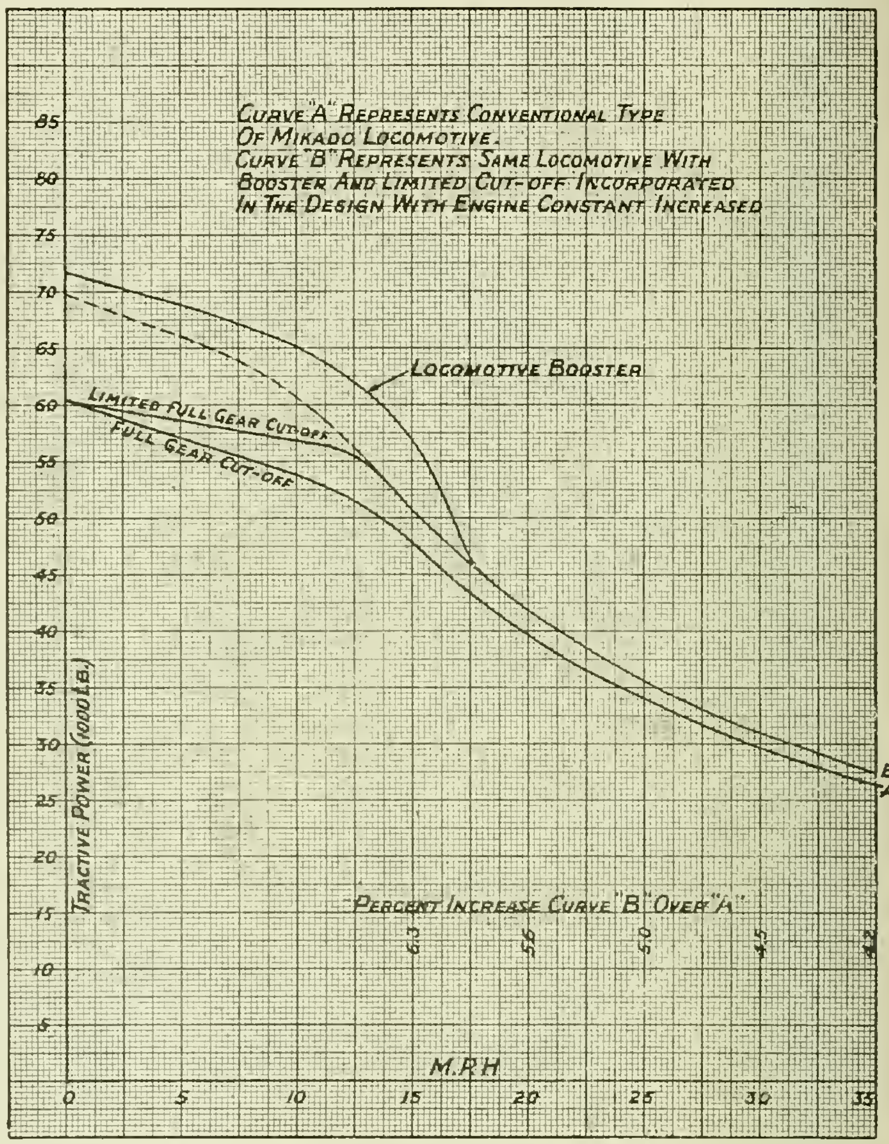


Chart No. 4

Chart No. 5 shows the rotative effort curve or torque curve of the Mikado engine represented by curve "A," at start, which shows that the peak is 25.3 per cent over the mean. If the new locomotive is started in full gear cut-off, as represented by the dotted line on curve "B," chart No. 4, this same rotative effort curve would exist.

When the limited cut-off is designed into the engine with the Booster, the rotative effort curve experienced is along the line as shown by Chart No. 6, and exerts as much power at zero speed as curve "A." This may be taken as the best possible rotative effort curve, with the minimum full gear cut-off, as can be obtained with a two cylinder, 90° engine.

As one is for 90 per cent and the other for 50 per cent cut-off, anything in between these two cut-offs will give a definite rotative effort curve at start which will be better than is experienced on full gear cut-off of the conventional type locomotive, but the very outstanding features about the incorporation of the Booster and limited cut-off into the locomotive shows that, along with obtaining a smooth starting locomotive, considering now approx- of the engine is not a limiting factor), by an increase in the steaming capacity of the boiler. This may involve a larger boiler or the application of a feed water heater or other heat conserving factors. Such an addition to the locomotive will not necessarily increase the weight on

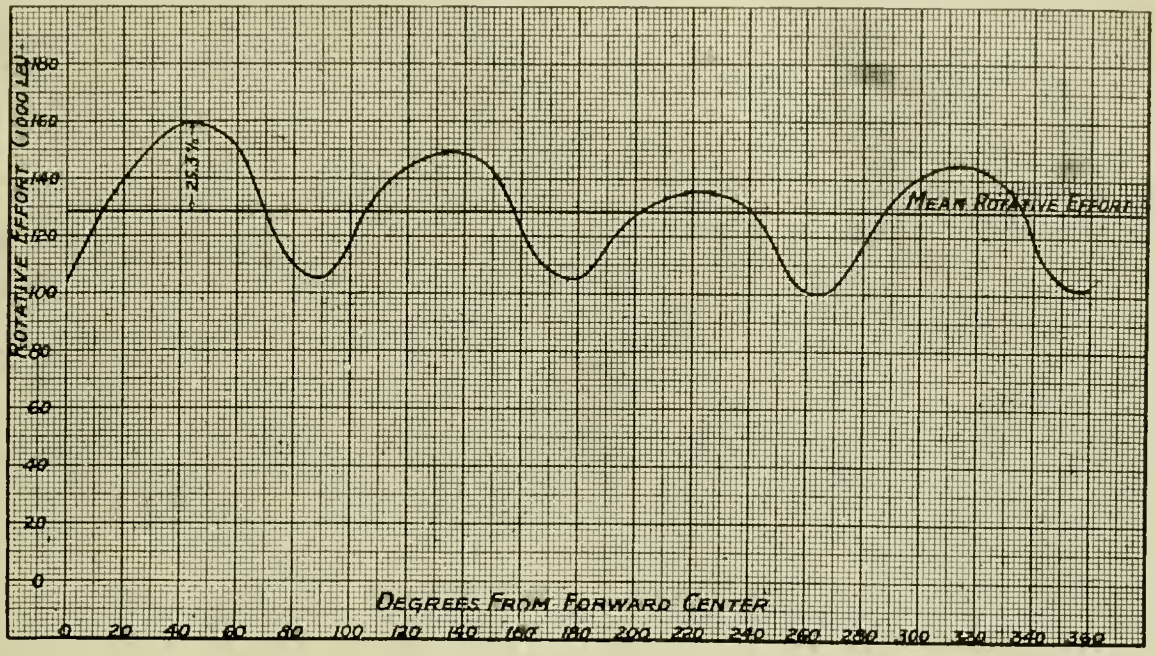


Chart No. 5 Showing Rotative Effort Curve or Torque Curve of a 27 in. x 30 in. Mikado Type Locomotive with 62 in. Driving Wheels—200 Lb. Boiler Pressure—Maximum Cut-off 90% of Stroke

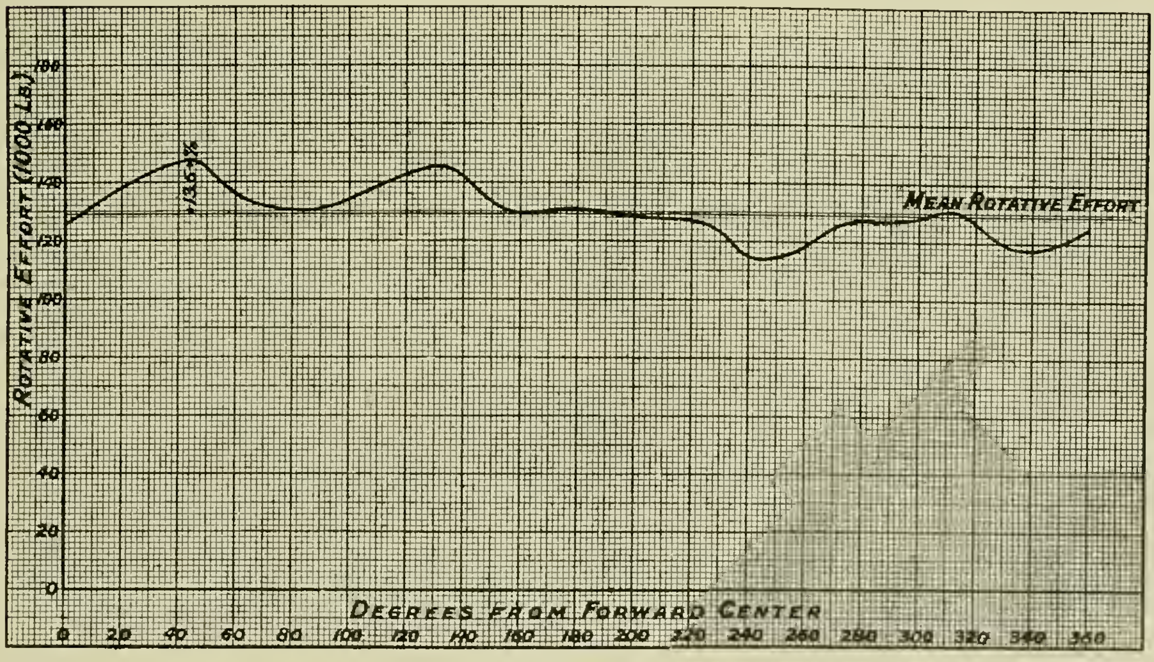


Chart No. 6 Showing Rotative Effort Curve or Torque Curve of a 27 In. x 30 In. Mikado Type Locomotive with 62 In. Driving Wheels and 250 Lb. Boiler Pressure—Maximum Cut-off 50% of Stroke

imately the same weight on drivers and same steam consumption, but with the engine constant increased, a greater power at high speeds, and a higher starting power than can possibly be secured in any other way.

Referring again to chart No. 4, the difference between curves "A" and "B" at speeds over 15 miles per hour can be still further increased (provided the total weight driving wheels, but will provide the requisite power to take care of the increased train load which the Booster can start.

No general rules or recommendations can be made to govern this matter as it must be decided by the mechanical department officers of the different roads to meet individual cases.

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The Automobile and the Railroad Crossing

For a number of years, in fact ever since the automobile became common property, the railroads have been trying to instill into the drivers of those machines some sense of their responsibility to themselves and the community, but, so far, with apparently little or no success. They have worked on the belief, that ideas which are given out by means of books, pamphlets, lectures and speeches will "be satisfactorily assimilated by hearers or readers, and that good ideas may thus be passed on for the uplifting of mankind. Here we have a great delusion."

The article in another column of this issue describing and illustrating the locomotive-automobile collision at Annandale, Minn., is a case in point. It is inconceivable to suppose that the driver of that automobile did not know that he *ought* to at least look in both directions before crossing a railroad track; but having crossed with impunity so often without taking any precautions he came, subconsciously, to think himself immune, and tried it once too often.

It is a problem, this recklessness of automobile drivers, that seems, to an onlooker, almost impossible of solution, and to railroad officials, who are making every effort to stop this slaughter at crossings it must be discouraging in the extreme.

Cases like the following can probably be paralleled by more roads than a few:

There was a crossing at which collisions were of common occurrence because the automobilist insisted on racing the train for it. First the railroad stationed a watchman there, but his warnings were disregarded and the collisions continued. Then the usual crossing gates were erected and lowered at the approach of trains. But the automobilist, in his hurry, broke through their light bars and did or did not immolate himself according as Fortune smiled or frowned. Then the gates were made of telegraph poles, and more than one machine was wrecked by the attempt of the driver to force his way past.

The railroads are obliged to report every accident to the Interstate Commerce Commission, that involves death or disablement for a period of two days. It is horrifying, and gives one a low opinion of the common sense of humanity, to go over these reports. Every month, year in and year out, on every road in the country, there are reports of drivers disregarding the warnings of signals, bells and watchmen, and driving upon the tracks directly in the paths of approaching trains. They and their friends are maimed and killed by the thousands every year, and still the merry dance of death goes on.

There is a saying about a sucker being born every minute. It can be paraphrased by saying that some reckless irresponsible buys an automobile every minute.

The electric railways have a rule requiring their conductors to leave their cars and go ahead to the track and look over it in both directions, at every grade crossing of a steam railroad; and this regardless of watchmen, gates or bells. It is a safe and sound practice. But it has been found impossible to get automobilists to even stop, look and listen, to say nothing of dismounting and going ahead in order to make sure. As a matter of fact the electric railway practice ought to be followed, for there is no one who cannot recall crossing tracks when and where it was not a matter of the merest chance that a train was not encountered.

The solution of the problem that will stop such accidents as that at Annandale is simplicity itself and appalling in its difficulties. Simple if automobilists would take the veriest of precautions, and unsolvable because of their character of foolhardy recklessness.

To the railroad it is more than serious. Usually the train escapes unscathed and it is only the reckless idiot and those who trusted their lives to his care who pay the penalty. But there is always the danger that the train may be wrecked, and a score of people killed or injured. What can be done to remedy the situation and prevent the slaughter? It will be a wise man who can make answer.

The Lehigh Valley Three Cylinder Locomotive

There is published elsewhere in the pages of this issue a description and the results of tests of the three cylinder locomotive which is in service on the Lehigh Valley Railroad. The indicator cards published in connection with the other data from operation tend to show the great possibilities of effecting economies and particularly with respect to fuel.

There are several important features of this new departure in locomotive design that are worthy of more than casual notice.

1. The advantages derived from three cranks at 120 degree angles gives a turning torque approaching closely to that of the four cylinder balanced compound brought out in 1902 with four cranks at 90 degree angles, but with a much less expensive and more practical crank axle, which by the way was the great, if not principal objection to the balanced engine.

2. Then again is the question of dynamic augment or hammer blow on the rail which is one of great importance, but unlike pounds of coal per ton mile, is hard to accurately estimate and convert into good American dollars. The riding qualities of this engine, however, together with

the uniform tractive power proves conclusively that in addition to increased tonnage hauled and decreased quantity of coal used per unit of service, an additional and very substantial credit may be made for saving on rails, bridge floors and in fact, the entire superstructure.

The Lehigh Valley in 1922 earned an average of $46,-754.00 per mile of road. Their freight trains averaged 760 net tons of revenue and non-revenue freight, their coal cost $5.04 per ton and they consumed 217 pounds per 1,000 ton miles, while this engine, No. 5000, produces 1,000 ton miles with about 66 pounds of coal, or a saving of more than 300 per cent, and although it is known that the annual average on all engines includes much fuel not included in this single test, yet the plain cold facts stand out so prominent that there seems to be only one answer to the fuel question. Stop some of it at once by improved methods, some by the application of inexpensive devices to existing power, and make still farther attacks on this great leak in operating expenses by the gradual substitution of improved design in the complete unit. The slogan should be:

"There is Millions to be Saved, and The Campaign is in Full Swing to Save It."

What will be the next road to follow the example of the New York Central and Lehigh Valley, and will these two lines continue to go forward not alone in the matter of improved design, but also in improving existing designs?

The Section of the Cast Iron Wheel

It is very safe to assume that any well-established practice which has been sanctioned by general consent or common usage, had, at its inception, some very good reason as the basis of its existence. So in the case of the section of the cast iron wheel; it was, possibly, properly described in a recent paper by Prof. Sproule in a lecture on metallurgy before the Engineering Institute of Canada, as composed of "graceful curves: the ensemble of which would make a nice architectural ornament." But when he goes on to say that "the idea that these curves afford any resilience is ridiculous on the face of it," and that "they don't help the moulder," it is at once evident that, however, well versed he may be in metallurgy, the gentleman is not conversant with the recent tests of car wheels as conducted by the University of Illinois or the requirements of a cooling wheel.

He showed a proposed design of cast iron wheel which he thought would eliminate two causes of cast iron wheel failure; namely the breaking of flanges and the cracking through the brackets and plates as a result of brakeshoe friction. He supports the tread of the proposed wheel by two plates each one inch thick and nearly straight, tying them together by one-inch round struts. There would be a number of advantages in such a design if it could be made: the straight plates, as he claims, would so support the tread that there would be little danger of stripped flanges; there would be no brackets; the moulding would be greatly simplified and the heat developed by brakeshoe friction would be dissipated by the circulation of the air between the plates.

Now what can be said for the standard section?

To start with a simple illustration, attention is called to the fact that the spokes of ordinary cast iron pulleys are almost invariably made with S-shaped spokes; and the reason is that, while they are red hot, they will bend sufficiently to compensate for the difference in the rate of contraction between the rim and the hub, and so cool without becoming cracked.

As for car wheels they were made with nearly straight plates at first, and it was in order to overcome the trouble with cracking, on cooling, that Washburn designed and patented the contour that has been developed into the present standard. The core and some other features were found objectionable, and to overcome this, a single plate wheel was once designed. But in order that it might be cast without cracking, the plate was corrugated. It was an easy wheel to mould and cast, but did not have the strength to sustain the thrusts of even the light cars of the later seventies, and so was never used extensively.

The attitude of the Pennsylvania Railroad in the matter is set forth in an article in another column, where the fact is brought out that when an increase was made in the carrying capacity of cars from ten to fifteen tons in 1876, it was found "necessary to abandon the old form of single plate cast iron wheel, that had been previously used, and definitely adopted the double plate wheel that has remained the general standard form ever since."

The car wheel committee of the Master Car Builders' Association has been working in conjunction with the Association of Manufacturers of Chilled Car Wheels for many years in a united effort to produce the best possible form of wheel, and the wheel evolved after all of this effort on the part of the greatest wheel experts in the country is the present standard wheel. It is the result of the consideration of hundreds of designs that were in use prior to 1904. We do not know that we have the best design, but we do know that we have one which is satisfactory. It is difficult for one without experience to appreciate the unequal shrinkage that takes place in radial and tangential directions, the one producing cracked plates and the other producing cracks across the tread of the wheel. The chilled iron wheel, in the course of its manufacture, encounters a multitude of contrary stresses which it would seem almost impossible to harmonize.

It is evident that the author of the paper looked at the proposition from a purely metallurgical standpoint, without regard to the peculiarities of cast metal subjected to expansion and contraction, both in casting and after it is in service.

Experience with wheels of different kinds that have straight members and straight plates, shows that they invariably give trouble on account of shrinkage cracks and internal stresses. Elaborate experiments have been made with different wheels having different shapes of curves, in order to determine those which gave the least trouble, and the curves which are now embodied in the standard wheel are those that gave the best results.

So much care and trouble has been expended in the development of these wheels that no change should be made or attempted on mere opinion, even though that opinion originates with an eminent metallurgical engineer.

This has not been written with the idea of setting up a man of straw for the purpose of knocking him down but because when a paper such as has been discussed is published under the ægis of a great technical association it receives an endorsement that will carry a great deal of weight, and would be apt to convey the idea that the railroads were careless or indifferent to the design of so important an item as the cast wheel, whereas quite the contrary is the case as the records of the Master Car Builders' Association will show.

Locomotive Lubrication

During the past year there has been published in our pages a number of articles on the subject of lubrication which dealt with various angles of the question and in which we have pointed out that no basis, easy of interpretation and successful application, has been developed for those charged with the care and operation of machinery.

At the last annual meeting of the American Society of Mechanical Engineers, a paper was presented entitled "A Graphical Study of Journal Lubrication," in which the author stated in his opening paragraph that in his paper, "An attempt is made to express the theory in a way that will be easily applicable to the solution of practical problems."

He followed this up with the use of graphic charts and mathematical formulae to sustain his theory, which was beyond the comprehension of any but highly skilled mathematicians.

In the discussion following its presentation a prominent railway officer said:

"I want to say that this is a very high class paper, so far as I am able to understand it, but, being merely a poor railroad man, I think it is considerably over my head, and I am hoping that when the author closes it, he will perhaps give me a little information on some problems which we have in the railroad, which are very serious.

"I hope it is not out of place to pick a particular problem. The locomotives have become so large and the limit of the clearance sideways is so definite, that the pressures on the crank pins have evidently reached a point where they have exceeded the possibility of lubricating satisfactorily.

"I know of a class of locomotives which has a 250 pound boiler pressure, a 30½ inch diameter cylinder, and the brass is about 9 by 9 on the crank pin. That makes bearing pressures of over 2,000 pounds to the square inch. We know that particular class of engine gives trouble when the work is required above a certain point; in other words, if we put that engine on a grade and give full boiler pressure to the piston and cut off at half stroke, those pins will be smoking hot in the first two or three miles. If we ease off on the throttle so that the train does not keep the speed which it should on the grade, the pins may cool off, but we have less capacity of the locomotive than that for which it was designed.

"That is a real problem. We must get out trains over the roads. We cannot stop to fix hot crank pins every two or three miles, or slack up on the throttle so that the engine will move the trains without burning up the brasses. It would be a great relief to me if the author could tell us what we ought to do. We have tried all kinds of lubrication. Our usual method is hard grease, but we are not getting the results that we ought to have."

We fully agree it was a most interesting paper, particularly to those who view these problems from a mathematical standpoint, and while it will no doubt be of much value to those who are following the theory of lubrication along these lines, we are free to admit our inability to give it practical application to the every day practical problems of the lubricating engineer, to whom, the author offered it as an easy solution of his problem.

Regardless of the degree of scientific effort employed or the accuracy of results reached by mathematical formulae, if the deductions are not so stated as to be available for intelligent use by the great body of engineers who design, build, operate and maintain machinery, then it will be of little value to those who are badly in need of, and are seeking aid in the solution of difficult lubricating problems. We are particularly interested in the subject from a railway standpoint. The problem of railway lubrication embraces 67,000 locomotives, 56,000 passenger cars and 2,400,000 freight cars. They alone represent 2,523,000 units.

The total annual cost of all lubrication to railways including shops, power plants, machinery, etc., is approximately $33,000,000. The cost to lubricate locomotives alone is more than $9,000,000. The locomotive equipment is of course diversified as to size, age and capacity, from the small eight wheel or American type with a total of about 14,000 square inches of area to be lubricated, to the largest articulated engine with more than 77,000 square inches. It might be of interest to here state that the wiping or rubbing square inches to be lubricated in a run of 100 miles by the small engine, amounts to more than 436,000,000, and with the large articulated engine 3,000,000,000 square inches, while the weight per square inch of projected area, and steam temperatures have constantly increased for many years past.

The manufacturers of lubricants and devices used in their application have quite a staff of experts, who working in co-operation with the railway company's mechanical officers, have for many years and are now working on these problems, and while they have accomplished much, yet some standard formulae, specifications, or definite instructions on a scientific basis, whereby any locomotive can be properly and satisfactorily lubricated has not been developed.

Vocational Training Urged by Senator Capper

We are educating 90 per cent of our youth to be white-collar workers, but have white-collar jobs for only 10 per cent, declares Senator Capper, of Kansas, in a recent editorial. The result of this over-production of white-collar workers is bound to be as disastrous, economically, as over-production in wheat or agricultural products, he says.

"Our industries clamor for the trained worker," says the editorial. "But our schools continue to turn out thousands upon thousands of young men and women fitted only for already over-crowded professions.

"Many different reasons are assigned by historians for the fall of the Roman Empire. Rome, however, did not fall until the Romans grew too proud to labor. Neither physically, morally, nor economically can any white-collar nation long endure. The fiber, stability, and soundness of American life depend on establishing the dignity of labor, not as a copy-book maxim, but as a national habit of mind."

What is needed in America today is a better balanced educational system, Senator Capper declares.

"A trade, vocational training for all is the complement of a balanced education," in his opinion. "Without such training for its citizens, the United States can not maintain its traditions, its national health, nor its place in the world. We must educate hand as well as head. Such training builds character as well as self-reliant independence. We in Kansas are beginning to see it and certainly none too soon."

British Lines Earn Substantial Dividends

The privately owned British railways which were amalgamated into four large systems at the beginning of 1923 are yielding 6 per cent to 8½ per cent on the dividend basis for 1923.

On the other hand, the railways of France which are, technically speaking, privately owned, but which operate under government guaranties and are so closely controlled by the government as to amount practically to government lines, showed startling increases in their already heavy deficits.

Simple Mallet Locomotives of the C. & O. Railway

New 2-8-8-2 Type for Heavy Freight Service

The Chesapeake & Ohio Railway has placed in service the first of a lot of 25 new simple Mallet locomotives of the 2-8-8-2 wheel arrangement which were designed under the supervision of J. H. Small, chief mechanical officer in co-operation with the builders, the American Locomotive Company.

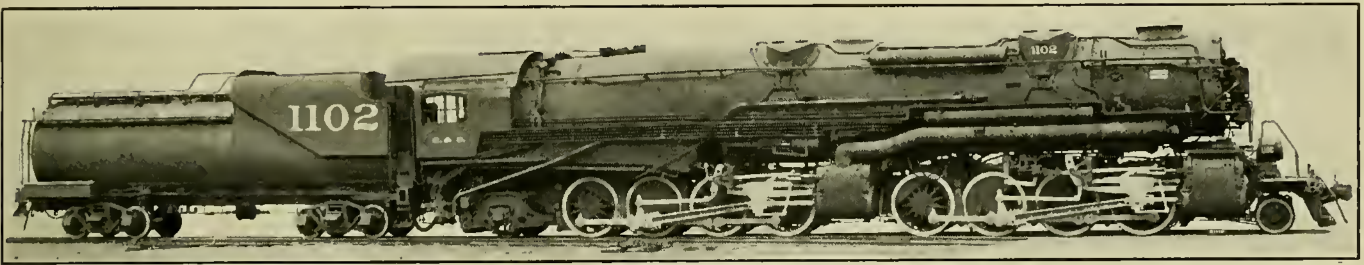
The engines are known on the C. & O. as the Class H-7 are to be used in the heavy coal service on the Allegheny Division between Clifton Forge, Va., and Hinton, W. Va., a distance of 80 miles, and in recent trial runs the locomotive showed its capacity by hauling 83 empty coal cars and two other cars, totalling 2,026 tons between Clifton Forge and Hinton in 4 hrs. and 42 mins. over grades of 0.4 to 1.14 per cent or at an average speed of 17.6 miles per hour. On the return trip from Hinton to Ronceverte a distance of 34 miles, with ascending grades of 0.34 to 0.4 per cent, 4,900 tons was hauled, while from Ronceverte to Clifton Forge, the remaining 46 miles were a grade of 0.57 per cent and 18 miles long is encountered, 3,889 tons was hauled. The actual running time of the return run was 4 hrs. and 45 mins. or at an average speed of 16.7 miles per hour. This is an increase of over 35 per cent of the tonnage formerly hauled by the 2-6-6-2 type compound engines which are classified the H-6 type.

A comparison of the general dimensions of the Class H-16 Mallet compound and the Class H-7 simple Mallet are given in the accompanying table.

In the new simple articulated engines the two sets of cylinders are 23 in. by 32 in. and develop 3,902 horsepower. The weight on drivers is 491,000 lbs., which with the tractive effort of 103,500 lbs., gives a factor of adhesion of 4.74.

The boiler is of the straight top type designed for a steam pressure of 205 lbs., and using Cole's ratios, develops 3,587 horsepower, which is about 92 per cent of the cylinder horsepower, not including the increase obtained from the use of the Elesco feed water heater. It is conical in form, being 93⅞ outside diameter at the smoke box and increasing to 101⅞ outside diameter at the combustion chamber, which is 74 in. long.

The fire box is 204⅛ in. long and 96¼ in. wide, equipped with a Gaines arch, and has grate surface of 168 in. by 96¼ in. or a grate area of 112.29 sq. ft.



New 2-8-8-2 Simple Mallet Type Locomotive of the Chesapeake & Ohio Railway—American Locomotive Co., Builders

	Class H-6 Compound Mallet	Class H-7 Simple Mallet
Type	2-6-6-2	2-8-82
Service	Freight	Freight
Cylinder, diameter and stroke	22-35-32	23x32
Valve gear type	Walschaert	Walschaert
Weight in working order:		
On drivers	368,500 lbs.	491,000 lbs.
On front truck	23,000 lbs.	32,000 lbs.
On trailing truck	49,500 lbs.	42,000 lbs.
Total engine	441,000 lbs.	565,000 lbs.
Tender	208,800 lbs.	209,000 lbs.
Wheel bases:		
Driving	30 ft.- 6 in.	42 ft.-0 in.
Rigid	10 ft.- 0 in.	15 ft.-9 in.
Total engine	48 ft. 10 in.	58 ft.-1 in.
Total engine and tender	86 ft.-11¾ in.	97 ft.19⅛ in.
Wheel diameter, outside tires:		
Driving	56¼ in.	57 in.
Front truck	30 in.	30 in.
Trailing truck	45 in.	42 in.
Boiler type	Straight Top	Straight Top
Steam pressure	200 lb.	205 lb.
Fire-box, length and width	108x96 in.	204⅛x96¼ in.
Grate surface	108x96 in.	168x96¼ in.
Arch tubes, number and diameter	4—3-in. O. D	None
Combustion chamber, length	82 5/16 in.	74 in.
Tubes, number and diameter	234—2¼ in.	278—2¼ in.
Flues, number and diameter	36—5½ in.	60—5½ in.
Length over tube sheet	24 ft.-0 in.	24 ft.-0 in.
Grate area	72.2 sq. ft.	112.29 sq. ft.
Heating surfaces:		
Fire-boxes combustion chamber	345 sq. ft.	467 sq. ft.
Arch tubes	24 sq. ft.	None
Tubes and flues	4,531 sq. ft.	5,980 sq. ft.
Total heating surface	4,900 sq. ft.	6,447 sq. ft.
Tractive power	*94,000-†74,200	103,500

The tractive effort, simple, of the H-7 is 10% more than H-6.
Compound, the H-7 is 40.8% over the H-6.
The draw bar pull of the H-7 is 50% over that of the H-6.
*Simple.
†Compound.

The first of the engines delivered were not equipped with the feed-water heater, but the Elesco equipment has since been installed on all of the 25 locomotives. Our illustration shows the engine before installation of the feed-water heater.

Duplex stokers which have given good service on the C. & O. engines are used for firing the large boilers. It is said that the stoker is here called on to perform the most strenuous work since it was invented.

An outstanding feature of the engine is its equipment of two powerful fans for eliminating tunnel gases. They were installed after exhaustive tests by the mechanical department in conjunction with experts from the Department of Interior, Bureau of Mines. The fans are located, one on the engineer's and one on the fireman's side, with the intake pipes underneath the cab decking and intake between engine and tender. Two type K-2 Pyle-National headlight turbo generators are installed beneath the floor of the cab, but in place of the generator in the headlight motors two fans were applied in such a manner that the motors were converted into blower fans. The air intake pipes are located under the engine deck in such a position that relatively pure air is forced into the cabs, and their use, as tested while the engines were in tunnels, has demonstrated that comparatively little of the exhaust gas is admitted to the cab while the volume of air furnished by the fans is sufficient to eliminate heat.

The tender is of the Vanderbilt type, equipped with Commonwealth Steel Co., cast steel under frame and Andrews truck frames. The tank has a capacity of 15 tons of coal and 12,000 gallons of water.

The Pennsylvania Railroad and the Development of the Freight Car

The Influence of Theodore V. Ely, Superintendent of Motor Power

By GEO. L. FOWLER

As in the case of the locomotive there are two distinct classes, the passenger and freight, so the same conditions obtain with cars except that the differences between them are more accentuated. In locomotive work, one engine can be made to haul a passenger or freight train indiscriminately, but cars designed for freight are not used for passenger nor are passenger cars used for freight. Though, as we shall see the rule is not an inflexible one.

When Mr. Ely entered railway services in 1868, the standard freight car of the country had a capacity of ten tons, and weighed about the same amount, so that for each pound of paying freight, there was a pound of dead car weight to be hauled. The use of a power brake, under the control of the engineer, for freight cars was not even thought of, and though the automatic coupler was a dream of an occasional visionary enthusiast, its realization was still more than two decades ahead.

But the period was closely following on the civil war, and the hard times and panic of 1873 were approaching. It was a period of retrenchment and economy, and the railroads were casting about for means of increasing net revenue by cutting down operating expenses. The most apparent means of accomplishing this was to increase the capacity of the freight cars, thus reducing the ratio of dead to paying weight, and increasing the net revenue per train mile. To which must be added the increase of total train load, by the enlargement of the locomotive. As to how this latter has been accomplished we have already seen.

The car, then, as well as the locomotive was a point of attack by the progressive superintendent of motive power and the car builder.

The story of the development of the freight car is, to a great extent, one of details rather than of radical and sweeping changes of design. In external appearance the car of 1924 does not differ materially from that of 1870. It is larger, is very evidently stronger and heavier and can carry a heavier load, but its shape is about the same. However, if the details are examined they will be found to be quite different in the two cars. In 1870 wood was the prevailing material for construction. It was used for the sills, bolsters, and framing and the metal parts of the car were limited to trussing, bolts, the draft and running gears. Now wood has become an auxiliary material, and steel is used wherever it is possible to work it in. It came first into the bolster construction; supplementing the wood as flitch plates set between planks for stiffening purposes and then taking its place exclusively. Still the great changes have been made along the lines of increasing the size and strength of the several parts. This is, perhaps, as marked in the case of the axles as in any other part. In 1870 the standard axle had a journal 3¼ inches in diameter and 7 inches long. Today the cars of 100,000 lbs. capacity are carried on axles 5 inches in diameter and 9 inches long.

This upward trend in weights and car capacities started in the early seventies just after Mr. Ely entered upon his railroad career, and when he was appointed superintendent of motive power at Altoona in 1874 he found the pressure in existence and constantly increasing to reduce expenses by increasing the ratio of paying to dead weight on the cars, and so adding to the net paying tonnage of the train.

So, we find that in 1876 he built a number of coal cars of fifteen tons capacity, for the road; and these were quickly followed by the box cars of the same rating. This increase of fifty per cent in the capacity of the cars, while it did not involve the same increase of dead weight, still added so much to the burden to be carried by the wheel that he found it necessary to abandon the old form of single plate cast iron wheel that had been previously used, and definitely adopt the double plate wheel that has remained the general standard form ever since. At the same time, it was realized, that, with the increasing loads, there was need of a better metal for the wheels, with the result that the Hamilton mixture was adopted for use in all wheels made at the Altoona foundry. This consisted of an addition of about 10 per cent of steel rails to the ordinary charcoal iron that was used. A move that put the cast iron wheel in a secure position for many years.

Meanwhile, the success of the cars of thirty thousand pounds capacity was such, that those of forty thousand pounds soon followed and after 1879 no cars of a lighter rating than that were used.

Then followed the rapid increase in capacities. The first step was to raise the sides of the gondola cars in 1880 adding about two and one-half tons to their capacity, then came cars of fifty thousand pounds and shorty after those of sixty thousand pounds capacity, so that, by 1888, the cars of the later size might be considered the standard of the country. This was the growth of the first twenty years of his service.

When the capacity of the standard box car had risen to 60,000 lbs. through the normal but rather rapid development, which has been outlined, there was a disposition on the part of some railway officials to call a halt. Not because of any physical danger resulting from an increase of capacity, but because of the impossibility of securing full loads for the cars already built. A movement was on foot to secure the adoption of standard dimensions for box cars through the agency and influence of the American Railway Association, but even on the Pennsylvania there were strong influences at work against an increase of load-carrying capacity. The argument brought forward against the move was that under the ordinary conditions of traffic, the average box car of 60,000 lbs. capacity received and carried only about forty-eight loads a year and of these only about one in ten was up to the full capacity of the car. If, then, the capacity were to be increased to 80,000 lbs., as was then suggested, it would be at an additional expense of about fifty dollars per car, and an added dead weight of about three thousand pounds, so that only five times a year would the large car haul twenty thousand more pounds of freight than the car of 60,000 lbs. capacity, or a total of one hundred thousand pounds of paying freight, while for forty-three times during the year the haul would have three thousand pounds of extra dead weight.

This was in 1899 and Mr. Ely, as an advocate of the increased car capacity, prepared an elaborate analysis of the situation.

In reviewing the matter, he called attention to the fact that, as early as 1890, in anticipation of heavier loads the body of the box cars of the road was designed so as to be capable of carrying eighty thousand pounds, although at that time, they were not prepared to use trucks of a higher capacity than sixty thousand pounds. During the ten years that followed the development of the eighty thousand and one-hundred thousand pounds metal truck for other classes of cars, naturally raised the question as to whether the trucks of this same type, should not be designed for cars of sixty thousand pounds capacity to take the place of the old design with wooden bolsters. After going over the subject, Mr. Ely recommended that it would be unwise to build any more trucks having a capacity of less than eighty thousand pounds and that course was pursued. Consequently, at the time that the matter came up for a final decision in 1899 many cars of the increased capacity had been built and were in service. About four thousand cars had been built during the previous year, under which the eighty thousand pounds capacity trucks were used; and, as the body had been raised to that capacity sometime previously, the result of the combination was the full fledged box car of eighty thousand pounds capacity.

In answer to the objection as to the greater cost and weight of the car, Mr. Ely showed that the difference in cost was $47.60 the interest on which at four per cent would be $1.90 per year.

This additional cost, due almost entirely to the trucks, would be made up by the less cost of maintenance, greater durability, better lubrication and greater factor of safety through the use of the more sturdy truck, even if the cars were not loaded to their full capacity at all times.

As to the extra weight of the car, which would be about three thousand pounds, he called attention to the fact that the road was already building cars of other classes to carry very heavy loads and that the construction of the body of the box car should be such that they can take their places in mixed trains without distress, and, therefore, that the increased weight of the truck should be the measure of the increase. But, as it stood, the car of eighty thousand pounds capacity would carry twenty-two per cent more pounds of paying load to a pound of car than the one of sixty thousand pounds capacity. What this actually was, was indeterminate but the average box car load was assumed to be fifteen tons. He then proceeded to show that, even on the basis of but five full loadings a year and the haulage of the extra three thousand pounds during the whole of the remainder of the time, and with the current costs per ton mile haulage, a single excess load of seven tons, of paying freight hauled eight hundred and fifty-seven miles, or from Chicago to New York would pay for the cost of hauling the extra three thousand pounds during the whole of the remainder of the year.

From this it appeared to him that the serious phase of the problem was not the extra cost and weight of the cars of eighty thousand pounds capacity, but that the road was not securing full loads in either direction for cars of any capacity.

As remedies for this great evil, he suggested a change in the rules for loading grain, in accordance with which any trans-shipment had to be made car for car regardless of the capacities of the receiving of delivering car. And that it would be well to work out some satisfactory plan with elevator owners and shippers, by which this state of affairs could be remedied and full loads secured to the railroad companies.

He recognized, however, that, with the existing facilities, at the elevators, it was impossible to load cars of eighty thousand pounds capacity to the full; but suggested that this was a difficulty easily remedied.

He concluded that if a car of a certain capacity could be moved, when loaded from one terminal to another with greater economy than a car of less capacity, every effort should be made to see that it is loaded to that capacity, expeditiously and unloaded, at its destination, with despatch using every measure to accomplish that end.

As the cubic contents of the sixty and eighty thousand pounds capacity cars were the same, an increase of length of two feet for the latter would add space for about four thousand pounds of grain. Mr. Ely did not advocate such an increase because he felt that an attempt should be made to load the existing cars to the full, since an increase of two feet would make a serious reduction in track capacity. By an increase of the box cars to a capacity of eighty thousand pounds, without increasing the length of the cars, the nominal capacity of yards and terminals would be increased about 33⅓ per cent. As the acquirement of such facilities is rapidly becoming more and more difficult it was urged that every care should be exercised to guard every inch in the length of the cars, and that the best endeavors should be used to make the loads higher. He also recommended that the policy which the road has pursued for years of gradually increasing the capacity of rolling stock should be continued, and that the box car should be made to fall in line with the other classes of equipment, which are fitted with trucks of eighty thousand pounds capacity. And, further, that, in the future, the road should not consider a truck of a lower capacity because cars that are built new, will remain in service for fifteen years, and, if the future is to be judged by the experience of the past, they will not at the end of that time be considered cars of high capacity.

In 1902 the matter was up again for further consideration and Mr. Ely reiterated his formerly expressed opinion as to the desirability of using cars of eighty thousand pounds capacity, but modified because of the important element of metal under-frames that had been introduced in the meantime.

It was decided in a full conference of the mechanical officers that the old wooden underframing with its attachments was not strong enough to withstand the stresses and shocks arising from the use of the heavier locomotives and trains, and so metal underframes were adopted as standard.

In the meantime, too, the American Railway Association had adopted a standard size of box car, which was slightly larger than the previous Pennsylvania standard.

It was found that the use of the metal underframe added largely to the cost of the car. So that, if the old size of the car had been retained, the revenue could not have been increased, but by making the box larger, at a small additional expense, an opportunity was offered to load a larger bulk, and thus increase the earning capacity of the car. Then, as the size of the box, so made, would be more than sufficient to hold more grain and like material than the trucks would carry, it was decided to spend a further small additional sum and make the capacity of the trucks, and thus of the whole car, one hundred thousand pounds.

Thus, after the normal development up to a capacity of sixty thousand pounds, what might be called outside influences were so brought to bear upon the question of high capacities for box cars, that it was rapidly forced by the logical sequence of events up to eighty thousand and then to one hundred thousand pounds.

The most potent of these outside influences was probably the development of the high capacity car for the coal and ore trade.

For a number of years beginning in the later eighties, the use of steel for certain parts of car construction, in the place of the wood previously used, had been rapidly increasing. Especially was this true in the matter of pressed steel shapes. So, too, there had been a long agitation of the use of an all-steel construction especially for gondola cars. Numerous attempts had been made to build such cars but the designers had handicapped themselves by attempting to produce a car that should neither weigh more nor cost more than the ordinary wooden car. It was not until 1897 when the Pittsburgh, Bessemer & Lake Erie R. R. purchased some steel hopper bottom ore cars of 100,000 lbs. capacity that the steel car of that high capacity can be said to have been firmly seated in the saddle as one of the elements of American railway practice.

The operation of these cars was watched with the closest attention by Mr. Ely and the other mechanical officers of the Pennsylvania, and so satisfactory was their work, and the economies resulting from their use were so apparent, that an order was soon placed for similar cars for the road.

This introduced the element of exceedingly heavy units in mixed trains to which Mr. Ely alludes, and it was for the protection of the other units of the train against the stresses set up by these extra heavy cars, that Mr. Ely advocated a general advance all along the line and the resultant increase of box car capacities, to one hundred thousand pounds.

This does not mean that all cars built by the company since that date have been of that high capacity, but the conditions are there and have been cited in this detail to show Mr. Ely's advanced attitude on the whole subject of an increase of car capacities in order to meet the requirements of the service.

It will thus be seen that there was a constant upward trend in the development of car capacities during the whole period of Mr. Ely's administration, starting with a standard capacity of ten and ending with one of fifty tons.

Meanwhile there were occasional aberrations, as it were, from the normal growth. Leaps ahead to show possibilities and to meet certain exigencies.

The first of these is to be found in a special car of one hundred thousand pounds capacity that was built at Altoona in 1888 and was the first of its kind. It was intended for the transportation of heavy concentrated loads. The body was carried upon four ordinary freight trucks arranged in two groups, connected by a girder on which the body itself was centered. It was an all steel construction. It was used for carrying a twelve-inch breech-loading rifle for the cruiser Monterey from the Washington arsenal to San Francisco, and was the predecessor of another, a special car that was designed to carry a Krupp gun from the seaboard to the Chicago Exposition of 1893. This gun which weighed 270,000 lbs. was the heaviest piece of single freight ever transported, up to that time on a railroad in the United States. The car which was designed and built at Altoona, consisted of four eight wheeled cars placed in two groups of two each. The two cars of each group were connected by a short bridge, carrying a center plate on which the major bridge, connecting the two groups rested. This major bridge formed the cradle on which the gun rested, and had a length of fifty feet from center to center of its supports. It was carried directly on its side bearings while the two short bridges were supported by their center plates. The car and its lading attracted a great deal of attention at the time, both because of the novelty of its design and its great carrying capacity, which was 285,000 lbs. It was built entirely of boiler plate, and weighed 175,000 lbs. when empty, so that the total weight of the car, with the gun and all of the appurtenances used for holding it in place, was about 460,000 lbs. This was carried on thirty-two wheels, giving a distributed load of more than fourteen thousand pounds on each wheel. At the time this was high but it has since been exceeded by the wheel loads of the ordinary freight car in every day service.

In contrast to this luxurious car for the transportation of a huge piece of steel, attention may be called to the adaptation of the freight car to passenger service that was made by Mr. Ely at the time of the Centennial Exposition at Philadelphia in 1876. It was the first really great international exposition that had ever been held in the United States and all classes of the people were anxious to attend. The Pennsylvania road was the only through line reaching the city, and it devolved upon it to carry the great mass of travel from the north, south and west. Its equipment and other facilities were taxed to the utmost and even then failed to meet the requirements. In order to increase these facilities and at the same time make it possible to lower the fares to a third class rate, large numbers of box cars were fitted with seats and run on a slow passenger schedule. Thousands of excursionists were carried in these cars, without accident and at low rates.

In this development of the freight car that has taken place since 1868, we have seen it emerge from a structure entirely of wood save for the necessary metallic parts and become one of steel throughout, in the case of the hopper bottom coal and ore cars, and with wood practically as an auxiliary to the steel forming the major portion of the construction.

Snap Shots—By the Wanderer

It is interesting to note the difference in the progress towards adoption of a device that has someone pecuniarily interested in its adoption and one that has no such promoter. How the one may leap into almost universal usage and the other because of the innate disinclination of the human mind to change, will lag along and be decades in receiving its due recognition.

For example, it was many years ago, more in fact than the man on the shady side of forty likes to mention, that Mr. Appleyard, I think it was, burst away from the old time parcel rack that a lady's reticule would overload, and put in that broad continuous rack running from end to end of the car, that was a characteristic feature of New Haven passenger cars as distinguished from all others, for so many years.

I have urged its adoption also in season and out, not to much avail, to be sure, but as my bread and butter did not depend upon it, my influence has been practically nil.

Generations of railroad men have come and gone, and this very good and convenient thing has been as slow in developing into anything like common usage, as it would take Dame Nature to evolve a new species. Everybody recognizes it as good, but having always put up little racks the sluggish mind of the average man fails to take it up. Still it is coming, I hope. Some day perhaps there will be a sudden and unexpected jump ahead and we will see—no, not we, but our children's children will see it in a Pullman parlor car. But we of this and the next generation will continue to pack our valises between our seats and the wall, and twist our feet to keep away from them. I wonder if the fashions would ever change if every woman was her own dressmaker and every man his own tailor.

Speaking of Pullman cars naturally suggests the porter. It would afford an interesting insight into human psychology—we seem to be running that way in these shots—if the porters of a few sleeping and parlor cars could be paid the equivalent of their tips, to reform from thrusting their services upon the passengers, unless they were asked with the understanding that, if asked, they were to do what was wanted willingly and cheerfully.

How many passengers would ask to have their boots blacked? Of course it goes without saying that the berths should be made up. But how many men want the porter to brush them off? That is as the porter does it. May Heaven forgive me, for so much as insinuating that it ought to be called brushing. Modern travel is not what it was. Stone ballast has done away with the dirt from below, and the brick arch, the well-constructed front end and proper drafting have pretty much done away with the dust from the stack. So we don't need the dusting that we did in the days of gravel ballast, archless fire-boxes and the diamond stack.

However, we are discussing Pullman porters. How many passengers, under the regime of a not-to-be-tipped porter, would ask him to take his overcoat out of the reticule rack or carry his satchel to the door? Carry it twenty-five feet to the door when he expects to carry it himself several blocks to his office or hotel.

Now he checks the satchel for its twenty-five foot journey to the door. Why not? Mine looks like yours, so why not exchange? It has been done too often to be pleasant.

There is a science in this porter business. It is the wise one who starts his work at the rear of the car. Then if a passenger has the courage to refuse to deliver his baggage, or be brushed (God save the mark) or be helped on with his overcoat, the other prospective victims to the front, do not see this break and receive cheer and encouragement for a similar defection. Every man is obliged to depend upon himself and decide as to whether he will permit the hold-up or not.

But if the porter starts his work at the front, one or two bold spirits may wreak havoc with his tips. I have seen this spirit of independence follow down for half a dozen seats on each side of the car, until someone less courageous than his fellow yields and after that all was well—for the porter.

"So much one man can do
That does both act and know."

But perhaps we had all best acknowledge with Falstaff that we are cowards on instinct and let it go at that, when the porter bows and waves his brush and suggests that he touch us with it and for it.

Speaking of the attitude of the public towards the railroads, there is one idea that it has fixed in its head, to the effect that complaints receive no attention. The trouble is the complainants pour forth their troubles to the wrong person. Growling at subordinates is so utterly useless that it is worse than a waste of breath. Of what use to complain to a ticket agent of a conductor's incivility. The ticket agent is not responsible for the conductor's behavior and any one should know it. The place to go is to headquarters, and don't go there unless you know definitely what you have to complain about. If anything goes wrong state definitely exactly when, where and how it went wrong. Give the train, the day and the hour, and if possible the grade of the employe implicated. Then its dollars to doughnuts that, if the complaint is a proper one, the complainant will receive a courteous letter giving thanks for the information, and promising correction. And the promise will be kept. More than this, if the complainant happens to live in the town where the officer to whom the letter is sent is located, it is quite probable that a representative of the railroad company will call to talk the matter over.

Railroad officers don't bury such matters in the waste basket because it is a part of their job of keeping things going, to prevent all causes of just complaint.

Individually I have scores of bad practices on my list that have been rectified because of complaints.

But let me give a bit of advice on this point. Don't write your letter in the heat of the offence. It will do just as well to do it the next day, and don't make a chronic fault finder of yourself. If you find fault, you can also find good points. It doesn't do an employe any harm, after he has stopped in the midst of pressing duties to help you out of a trouble; if, when trains are late and snowbound, he asks the despatcher what you had best do to reach your destination, it doesn't do him any harm, I say, for you to write to his superintendent telling of what he has done. And then when the superintendent commends him, he feels more disposed to help the next fellow who comes along, who may happen to be your own good-natured self.

So don't adopt the public's stand and if you do write, invite both kinds of a letter.

Argentine Railways Prosperous

Argentine railways are looking forward to another period of prosperity and progress. Reports of the British-owned lines for the financial year ended June 30, 1923, show successful results for the period, and the outlook for the coming year is encouraging. Dividends on common stock for most of these roads were 7 per cent. Gross receipts on the principal roads were from 8 to 17 per cent higher than for the previous year.

Many improvements were made and much equipment renewed during the year. In spite of heavy increases in service, the operating expenses of practically all lines showed a reduction from last year. On one of the largest lines—the Southern—this reduction reached 5 per cent, and on the Entre Rios 8 per cent.

For the first time in their history the Argentine State Railways showed a profit. These lines extend nearly 4,000 miles, and were built primarily for the development of new sections of the country. Traffic has increased steadily, and internal reorganizations are being carried out in the operation of the lines. The gross receipts of the Central Norte Argentino, the largest of the State lines, were 20 per cent higher for the first four months of the present financial year than for the same period last year.

Increases in passenger traffic for the past financial year ranged from 4 to 15 per cent over the preceding year. The Central Argentino and the Pacifico, which are the main passenger arteries, showed increases of 15 and 12 per cent, respectively. All roads showed heavy freight increases.

One of the features of the year has been the increased use of oil for fuel on the Argentine railways. The State lines in the south have been using oil entirely, and during the past year the Central Norte has been receiving oil at the port of Santa Fe for use in its locomotives. The three British railways—Western, Southern, and Pacifico—operate a joint petroleum company at Comodoro Rivadavia. The Southern now has 236 locomotives equipped for oil burning, and last year 45 per cent of the fuel used was oil. The Western is now operating with 50 per cent oil-burning locomotives.

Shop Kinks

Handy Devices Used on the Erie R. R.—Machine for Moulding Compression Cup Grease—Brake Beam Straightening Device—Prony Brake for Air Motor

Compression Cup Grease

The forming or moulding of the grease that is used on rods and elsewhere is a necessary part of the preparation of the supplies of locomotives. The grease is delivered in barrels and must be moulded into cylindrical pieces about 2¼ in. in diameter and 2½ in. long.

The machine for doing this work that is shown here is one that was designed at the Hornell shops. The main working part consist of two cylinders set tandem to each other, and having pistons mounted on a single piston rod.

In one an air pressure is developed and in the other the grease is compressed and forced through a small opening of a diameter equal to that of the finished cylinder of grease.

Referring to the engraving *A* is the air cylinder and *B* the one in which the grease is compressed and formed.

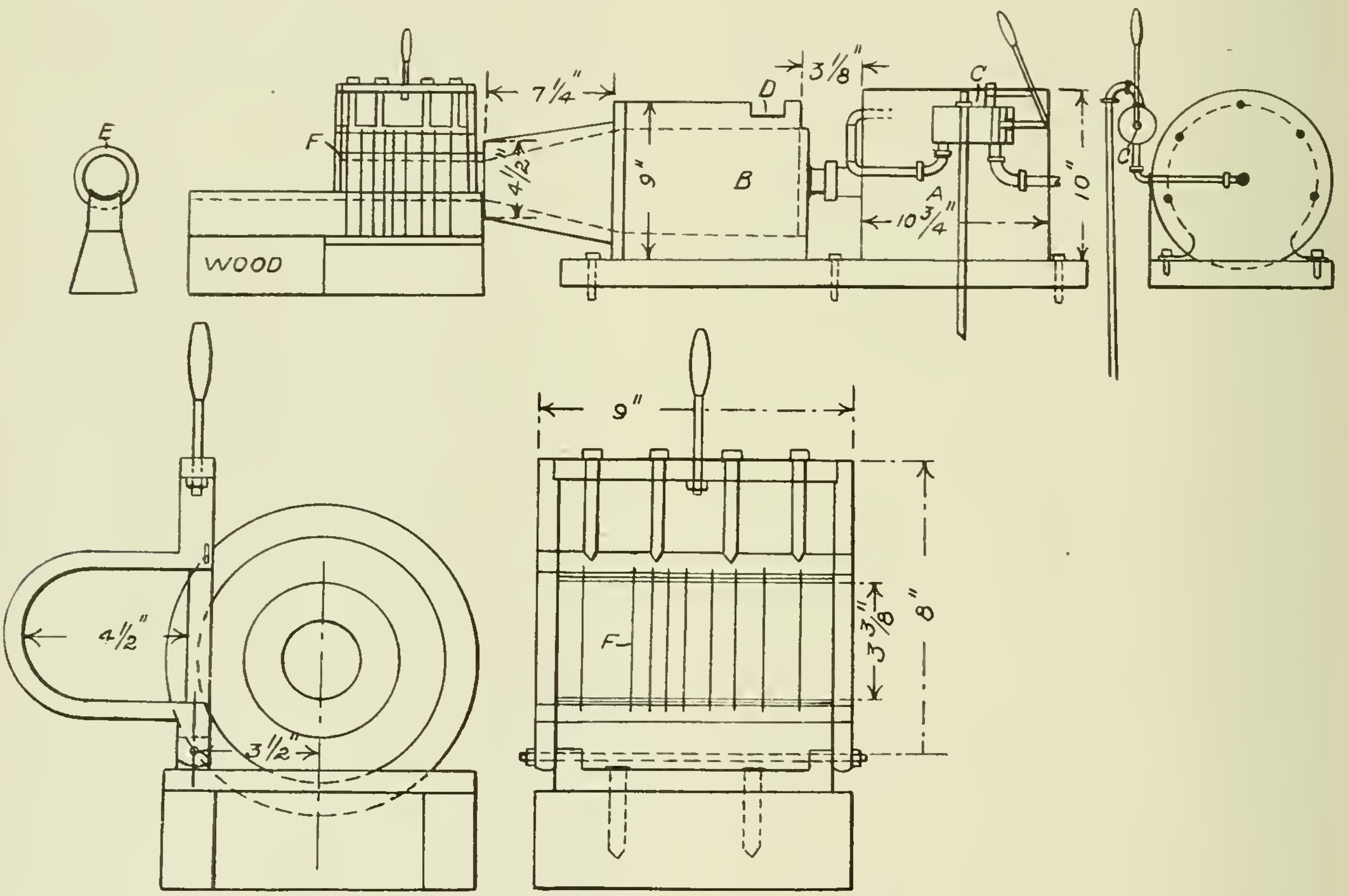
There is a three-way valve at *C* which is operated by a lever, and by means of which the compressed air can be admitted to and exhausted from either end of the cylinder. This cylinder has an internal diameter of 7 in. and a piston stroke of 7 in.; this, of course, being common to both cylinders.

The grease cylinder has an internal diameter of 6 in. and a total length of 10 in. This cylinder has no head at the end towards the air cylinder, but is closed by the piston itself, which is a plain disc, attached to the piston rod, and which stands flush with the end of the cylinder when retracted to the right hand end of its stroke.

At the discharge or left hand end of the cylinder there is a conical head terminating in an opening 2¼ in. in diameter.

At the right hand end of the grease cylinder at the point marked *D* there is a hole 2 in. wide and 5½ in. across cut in the wall for the insertion of the grease to be moulded.

In operation the space beneath this hole is filled with grease and air admitted so as to cause the piston to push it to the left. The piston is then withdrawn and the space again filled and the operation repeated until the cylinder is filled. A full pressure of air is then admitted to the right hand end of the air cylinder, by which the pistons are moved to the left and the grease forced out through the hole at the end of the conical head.



Machine for Moulding Compression Cup Grease

As the compressed and solidified grease leaves the head it is in the form of a cylinder 2¼ in. in diameter, and enters a series of brass rings *E* which are soldered to an iron support, with sufficient space between them to admit of the passage of the cutting-off knives *F* in the rack. These brass rings are 2¾ in. outside and 2⅜ in. inside diameter. At the end of this nest of rings there is a grooved iron trough into which the cakes of grease are pushed after they have been cut to length.

The cutting is done by a gang of blades each about 3½ in. long that are set in a frame resembling a hack saw

The bar holding the blades is 3/16 in. thick and ½ in. wide for the end next the pivot, it being sawed to receive the blades. The other ends of the blades, next the handle, are held by an iron rod ½ in. in diameter upon which they are strung. The saw kerfs at the lower end hold the blades at a proper spacing from each other.

It is evident that when the cylinder of grease has been pushed through so that its end has reached the outer edge of the nest of brass rings and is stopped there by shutting off the air supply to the right hand cylinder a turning of the gang of blades through 90 degrees will cut the long cylinder of grease into the desired lengths. Then another application of the air will push them out upon the open trough and leaves another cylinder in line with the blades to be cut.

The whole is mounted on a wooden base 2 ft. 6 in. long, 1½ in. thick and 10¾ in. wide. The cylinders are covered with a Russia iron jacket which gives them a neat and finished appearance.

Brake Beam Straightening Device

Under the stresses imposed by service or accident brake-beams are apt to become kinked or bent, a condition which subsequent service is sure to increase.

At the Meadville shops there is a simple and convenient device for straightening such beams.

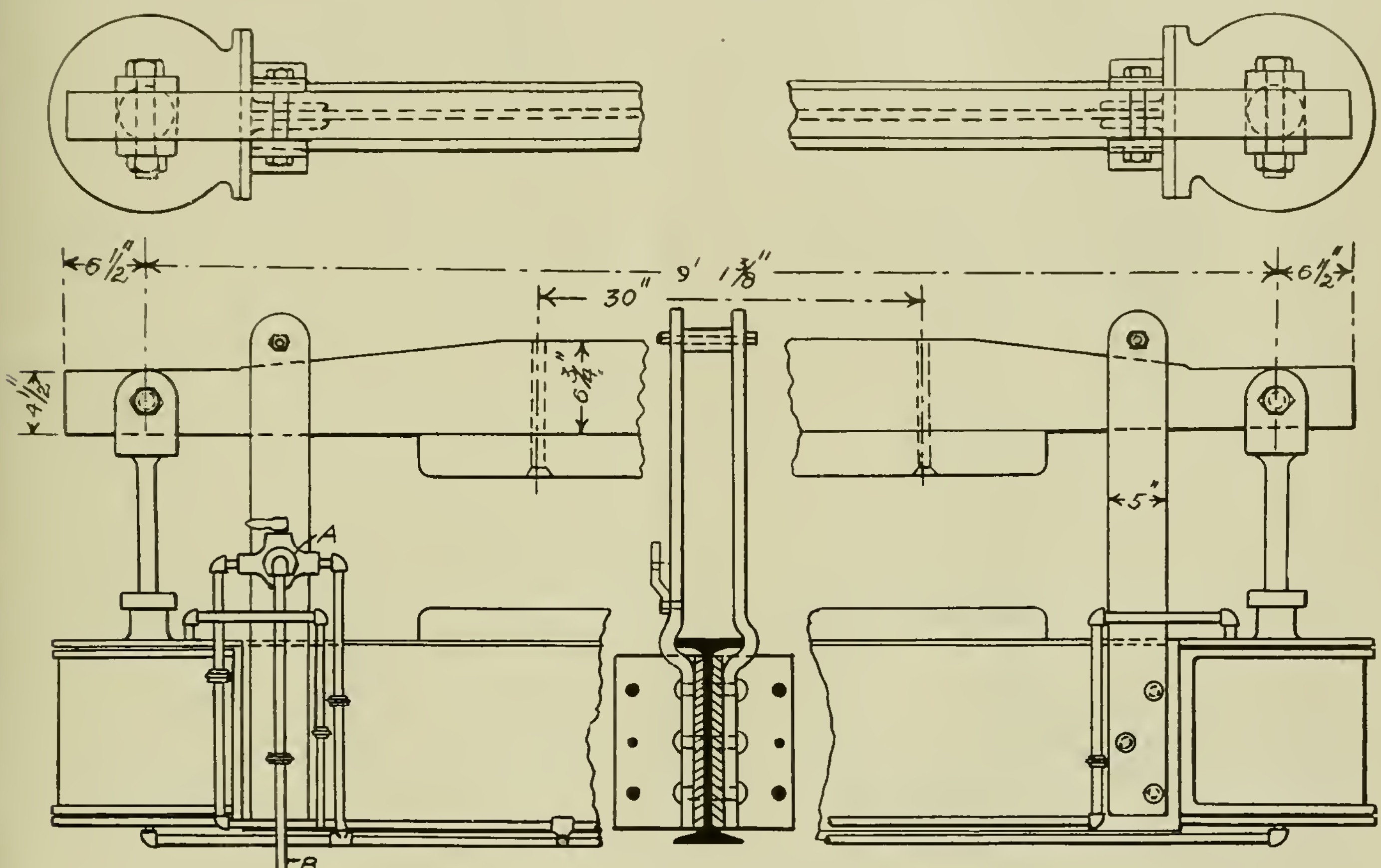
Like so many other handy shop kinks discarded air brake cylinders have been utilized as a means of developing the power required. In this case two 12 in. by 12 in. cylinders have been utilized. They are set vertically, and as shown in the plan their flanges are bolted to a casting securely fastened to the base or anvil, which is formed of a 15-in. I-beam, weighing 60 lb. to the foot.

These cylinders are set 9 ft. 1⅜ in. from center to center and are arranged for pulling downwards, though air is admitted to each end. The piston rods terminate in a jaw which is pinned to the working beam by 1¼ in. pins. This beam is made of a 6¾ in. by 3½ in. bar which is tapered to a depth of 4½ in. at the ends. Both the base and the working beam are protected by bearing pieces, doweled to the base and bolted to the working beam. At the ends of the base there are a pair of straps made of 5 in. by 1 in. flat steel to serve as guides, and they are spaced 3⅝ in. apart so as to permit of a free and easy movement of the working beam and yet keep it in proper alinement.

A valve at *A* takes air from the supply pipe *B* and admits or exhausts it from either end of the two cylinders.

The method of operation is apparent from the engraving. The beam is placed in position for being bent into proper shape and the work is done on the downward stroke of the pistons.

With a pressure of 60 lb. per sq. in. in the cylinders a pressure of something more than 13,500 lb. will be exerted by the beam.



Brake Beam Straightening Device

Prony Brake for Air Motor

The necessity for determining the power developed by an air or electric motor does not arise very often, but when it does a prony brake is about the handiest thing with which to measure it.

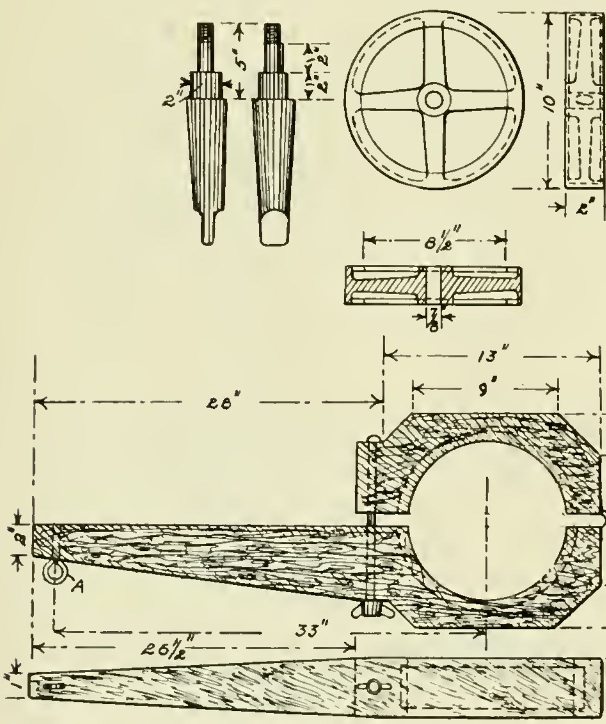
The brake shown here is a small affair and easily made. It measures only 41 in. by 13 in. by 3 in. overall. The brake is of wood. The two pieces may best be hinged at *A* with leather while the clamping can be done with a ½ in. bolt and thumb-screw. The brake blocks are of wood 3 in. thick and the eye *A* is set 33 in. from the center.

The pulley is of cast iron with a 2 in. face and an outside diameter of 10 in. It has internally projecting flanges in the usual way for prony brake pulleys, and of a depth sufficient to hold the necessary water for cooling purposes. The brake parts are recessed to a depth of 1 in. so as to receive the pulley and be held in alinement.

The pulley is bored out to ⅞ in. diameter and cut for a ¼ in. by ¼ in. key that is fitted into the shank or shaft. This is just long enough to afford a seat and clearance for the pulley and for the Morse taper shank that fits into the motor. In the making of the two parts of the brake it is well to use a hard wood, such as oak, ash or chestnut and before putting it into service thoroughly saturate the braking end with oil. Mineral oil will do but lard oil is better. This gives the wood an initial lubrication and serves to protect it and prevent burning, when newly applied to the running pulley.

In order to use the device the Morse taper shank is placed in the spindle of the motor to be tested, and the motor fastened to prevent twisting. The pulley is then placed on the shank and the rim filled with water. It is well to do this filling while the motor is running because then the rim can be completely filled and a large volume of water used. However, if there is an objection to the spilling of the water when the motor stops it can be done while standing, in which case care should be exercised that it does not evaporate and run dry.

A convenient method of measuring the pull is to suspend the brake with a spring balance by the eye *A*. As the length of the lever arm in this case is 2.75 ft. the formula for the determination of the horsepower is to multiply twice the number of revolutions per minute by 3.1416, and this by 2.75 times the pull on the spring balance and divide by 33,000, or



Air Motor Prony Brake

$$\text{Horsepower} = \frac{2 \times 3.1416 \times N \times P \times 2.75}{33{,}000}$$

in which

N = Number of revolutions per minute
P = Pull on balance or load on scale

Boring Bar Truck

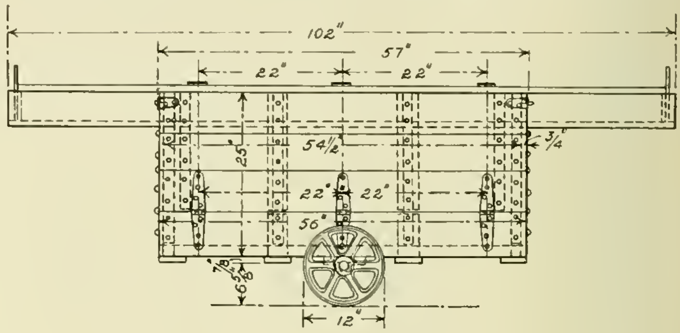
Boring bars for reboring cylinders and steam chests are heavy and with their attachments are cumbersome and difficult to move about.

The truck shown here serves not only to store the bar and everything belonging to it, but to move it from place to place as well.

It consists of a strong wooden box, measuring 23½ in. in depth, 42½ in. in width and 54½ in. in length on the inside. It is stiffened at the corners by steel angles and with cleats across the bottom and side.

It is mounted on a pair of 12 in. diameter wheels. One side is hinged just above the top of the wheel so that when it is turned down the whole of the interior is readily accessible.

At the top there is an extension projecting out for a distance of 23 in. on each end, that is arranged to take



Boring Bar Truck

the boring bar, and give it ample support. As this support is 8 ft. 6. in. long it is long enough to take the bars intended for use with even the largest cylinders.

Standardization of Freight Cars in England

A plan for standardization of railway freight cars has been arranged between the railway clearing house for the companies and the private car owners, by which all freight cars built in future will be of two standard specifications only—12-ton and 20-ton. This change, contemplated for years, may be attributed largely to the unification of railways under the act of 1921. Great savings are anticipated eventually from this plan, not only in facilitating repair and in aiding train assembly, but also in cheapening first cost and in promoting mass production.

Quantity output schemes are already being introduced at car-building plants. At Cardiff, an extension of the Crown Wagon and Engineering Works is under way to expedite the specialized construction of steel-frame box cars and the construction of the new 20-ton coal cars. The Great Western Railway serving that territory urges colliery owners to adopt the 20-ton size, and offers a 5 per cent rebate on coal traffic so carried.

English and Belgian Railways Joined by Car Floats

A daily service of train-carrying ferryboats has recently been inaugurated between Zeebrugge, Belgium, and Harwich, England, for the exchange of freight. The service is operated by the Great Eastern Train Ferries (Ltd.), an Anglo-Belgian organization capitalized at £400,000. The trains will run aboard the ferryboats at Harwich and Zeebrugge by means of gangways that are adjustable according to the tide. Specially constructed rolling stock has been built for the service. Transshipment will be eliminated, losses from theft and pilferage reduced, and there will be a considerable saving in the time and cost of handling.

The ferryboats are propelled by Diesel motors burning heavy fuel oil, and will take eight hours to cross the channel. Although capable of greater speed, this schedule has been agreed on for reasons of fuel economy.

Railway Fuel Association Convention

The International Railway Fuel Association will hold its 16th annual convention in Chicago, May 26 to 29, inclusive, with headquarters at Hotel Sherman. A local committee on arrangements has been appointed which has in hand the entertainment of visiting delegates. It is anticipated that the meeting will be one of the most interesting ever held. Tentative plans have been made for an exhibition of coal, coke, oil and general railway supplies at the hotel during convention week. The chairman of the local committee on arrangements is W. H. Harris, president, W. H. Harris & Co., coal and coke, 343 South Dearborn street, Chicago.

New Pullman Cars for the Pennsylvania

Fifty all-steel sleeping cars, of improved type and containing numerous innovations in interior arrangements, are being constructed by the Pullman Company for service on the Pennsylvania Railroad System. In their design special attention has been given to providing greater convenience for the increasing number of women who are traveling. Among the principal features of the new cars are greatly enlarged women's dressing rooms, each equipped with a full length "vanity table," large enough for four chairs, a mirror of extra size and three washstands.

The new cars contain twelve sections, each with upper and lower berth, and one drawing room decorated in dull walnut and upholstered with bright and attractive tapestry. The smoking room is also finished in light and cheerful style. Other features of interest include mirrors and "non-sagging" hammocks in the upper berths and ventilators with dust-excluding devices in all windows.

Fixed headboards are provided between the sections to afford greater privacy during the daylight hours of travel and speed up the work of making up and taking down the berths, thus shortening the time during which passengers must vacate their sections to allow the porters to work. Each headboard has a short sliding panel at the outer end, about eight inches in width, which locks in place when pulled out flush with the ends of the seats. When the berths are taken down, the sliding panel is pushed back slightly, thus widening the upper portion of the aisle.

The cars of this new type are intended for use on such high-grade, long distance trains as the "Broadway Limited," and the "St. Louisan," etc.

Notes on Domestic Railroads

Locomotives

The Southern Railway has ordered 20 switching type locomotives from the American Locomotive Company, also 5 Mallet type locomotives from the Baldwin Locomotive Works.

The Chesapeake & Ohio Railway contemplates buying about 50 locomotives.

The Florida East Coast Railway is inquiring for 20 Mountain type locomotives and 5 8-wheel switching type locomotives.

The El Paso & Southwestern Railroad is inquiring for 6 Mikado type locomotives.

The Union Pacific Railroad has ordered 20 Mallet type, and 5 Mountain type locomotives from the American Locomotive Company, and 10, 2-10-2 type locomotives from the Baldwin Locomotive Works.

The Louisville & Nashville Railroad has ordered 18 Mikado type, 6 Pacific type, and 6, 8-wheel switching type locomotives from the American Locomotive Company.

The Reading Company has ordered 5 Pacific type locomotives from the Baldwin Locomotive Works.

The Canadian National Railways has ordered 5, 2-10-2 type locomotives and 15 Mountain type locomotives from the Canadian Locomotive Company.

The Pittsburgh & West Virginia Railway has ordered one Pacific type locomotive from the American Locomotive Company.

The Wabash Railway has ordered one 8-wheel switching type locomotive from the American Locomotive Company.

The Clear Lake Lumber Company, Oregon, has ordered one Shay type locomotive from the Lima Locomotive Works.

The Pacific States Lumber Company has ordered one 90 ton, 3 truck Shea type locomotive from the Lima Locomotive Works.

The Commonwealth Steel Company is inquiring for one 6-wheel switching type locomotive.

The Siler Logging Company, has ordered one Mikado type locomotive from the Baldwin Locomotive Works.

The Shevlin-Hixon Company, has ordered one Mikado type locomotive from the Baldwin Locomotive Works.

The Reading Company has ordered 5, 8-wheel switching type locomotives from the Baldwin Locomotive Works.

The Southern Pacific Co. is inquiring for 6 electric locomotives.

The New York Central Lines is inquiring for 3 Mallet type locomotives.

The Union Pacific Railroad contemplates buying about 10 locomotives.

The Tennessee, Alabama & Georgia Railway has ordered one Consolidation type locomotive from the Baldwin Locomotive Works.

The Chicago, Rock Island & Pacific Railway is inquiring for 10 Mountain type locomotives.

The Utah Copper Company has ordered 3, 0-6-0 type locomotives from the Baldwin Locomotive Works.

The Atlantic Coast Lines Railroad has ordered 20 Pacific type and 5 switching type locomotives from the Baldwin Locomotive Works.

The New York, Chicago & St. Louis R. R. has ordered 10, 8-wheel switching type locomotives and 10 Mikado type locomotives from the Lima Locomotive Works.

Freight Cars

The Western Fruit Express Company has ordered 1,000 steel underframes from the Pressed Steel Car Company.

The Boston & Albany Railroad has ordered 100 box cars from the American Car & Foundry Company and 25 dump cars from the Western Wheeled Scraper Company.

The Southern Railway has ordered 250 all steel gondola cars from the Chickasaw Shipbuilding & Car Company.

The New York, Chicago & St. Louis Railroad has ordered 300 stock cars from the General American Car Company and 1000 automobile box cars from the Illinois Car Manufacturing Company.

The Utah Copper Company, New York, is inquiring for 6, 50-ton steel underframes for flat cars.

The Chesapeake & Ohio Railway is inquiring for 600 Hart ballast cars of 50 tons' capacity.

The Louisville & Nashville Railroad has ordered 100 Hart combination ballast cars from the Roger Ballast Car Company.

The Norfolk & Western Railway contemplates buying 2,000 box cars and also rebuilding a large number of hopper cars.

The Skelly Oil Company has ordered 35 tank cars from the General American Tank Car Corporation.

The American Smelting & Refining Co. is inquiring for 15 ore cars of 60 tons' capacity.

The Illinois Central Railroad has placed an order for the repair of 900 box cars and 195 flat cars with the Pullman Company and the repairs for 1,000 box cars with the Ryan Car Company.

The New York Central Lines has ordered 500 cars from the American Car & Foundry Co., 1,000 from the Pressed Steel Car Company, and 1,000 from the Standard Steel Car Company.

The Canadian National Railways has ordered 50 caboose cars from the Canadian Car & Foundry Company.

The Universal Portland Cement Company has ordered 50, 70-ton hopper cars from the Mt. Vernon Car Manufacturing Company.

The Baltimore & Ohio Railroad is reported to be inquiring for price on the rebuilding of 500 freight cars.

The Delaware, Lackawanna & Western Railroad has ordered 750 automobile cars 40 ft. long from the American Car & Foundry Co. and 250 cars from the Magor Car Corporation.

The Chicago, Burlington & Quincy Railroad is inquiring for 1,000 stock cars.

The Chesapeake & Ohio Railway is inquiring for 3,000 hopper bottom gondola cars of 57½ tons' capacity and 2,000 automobile box cars with steel frame of 40 tons' capacity.

The Kansas City, Mexico & Orient Railroad is inquiring for 500 single sheathed box cars, 250 stock cars of 40 tons' capacity and 250 gondola cars of 50 tons' capacity.

The Elgin, Joliet & Eastern Railway is inquiring for 500 coke cars.

The Louisville & Nashville Railroad has ordered 1,150 box cars, 500 automobile cars and 150 flat cars from the Chickasaw Shipbuilding & Car Company, 500 box cars from the Mount Vernon Car Manufacturing Company, and 1,100 steel gondola cars from the Pressed Steel Car Company.

The Central of Georgia Railway is inquiring for 10 steel underframes for caboose cars.

The Chesapeake & Ohio Railway has ordered 2 scale-test cars from the Southwark Foundry & Machine Company.

The Western Fruit Express Company is inquiring for 1,000 underframes.

The Union Refrigerator Transit Company will build 250 refrigerator cars in its own shops.

The Southern Railway has ordered 750 hopper cars from the Standard Steel Car Company and 1250 gondola cars from the Chickasaw Shipbuilding & Car Company.

The Fruit Growers Express has ordered 100 steel underframes from the Ryan Car Company, also 100 steel underframes from the Bethlehem Steel Company.

The Seaboard Air Line has ordered 25 ballast cars from the Rodger Ballast Car Company.

The Richmond, Fredericksburg & Potomac Railroad has ordered 15 ballast cars from the Rodger Ballast Car Company.

The Kingan Refrigerator Line, is inquiring for 100 refrigerator cars.

The Northern Refrigerator Company has ordered 500 refrigerator cars from the Pullman Company.

The Western Electric is inquiring for 4 logging cars of 40 tons' capacity.

The Youngstown Sheet & Tube Company is inquiring for repairs on 500 to 600 hopper cars.

Passenger Cars

The Atchison, Topeka & Santa Fe Railway has ordered 10 compartment coaches, 8 buffet library cars and 8 dining cars from the Pullman Company.

The Chesapeake & Ohio Railway is inquiring for 4 all-steel dining cars and 15 all-steel express cars.

The Wichita Falls & Southern Railroad has ordered from J. G. Brill Co. one model 55 gasoline passenger and baggage car.

The Southern Railway has ordered 25 steel coaches from the Bethlehem Shipbuilding Corporation, 12 steel combination baggage and express cars, 2 steel postal cars and 6 steel combination mail and baggage cars from the American Car & Foundry Company, and 5 steel dining cars from the Pullman Compnay.

The Clinton & Oklahoma Western Railroad has ordered from J. G. Brill Co. one Model 55 gasoline, passenger and baggage car.

The Bessemer & Lake Erie Railway is inquiring for 6 passenger-baggage cars, 3 baggage-mail cars and 3 baggage cars.

The Pittsburgh, Lisbon & Western Railroad has ordered from J. G. Brill Co., one Model 55 gasoline passenger and baggage car.

The San Antonio, Uvalde & Gulf Railroad has placed an order with the J. G. Brill Co. for one Model 55 gasoline passenger and baggage car.

The El Paso & Southwestern Railroad is inquiring for 3 buffet baggage cars and one dining car.

The Louisville & Nashville Railroad has placed an order for 20 coaches with the American Car & Foundry Company and for 8 baggage cars and 6 combination baggage and mail cars with the Pressed Steel Car Company.

The Canadian National Railways has placed orders for 20 coaches and 15 mail-express cars with the Canadian Car & Foundry Co.

The Montreal Tramways Co. has ordered 50 coaches from the Canadian Car & Foundry Co.

The Chicago, Rock Island & Pacific Railway is inquiring for 8 dining cars and 5 buffet cars.

The Virginian Railway has ordered one business car from the Bethlehem Shipbuilding Corporation.

The Atchison, Topeka & Santa Fe Railway is inquiring for 10 postal cars.

The Nashville, Chattanooga & St. Louis Railway is inquiring for miscellaneous coaches.

The International-Great Northern Railroad has ordered 3 coaches, one baggage and mail car and 4 baggage cars from the American Car & Foundry Company.

The Atchison, Topeka & Santa Fe Railway has ordered 6 business cars from the Pullman Company.

The New York, Westchester & Boston Railroad has ordered 10 steel passenger coaches from the Pressed Steel Car Company.

The Atlantic Coast Line Railroad has ordered 10 baggage cars and 7 combination mail and baggage cars from the Standard Steel Car Company.

The New York Central Lines contemplate buying a number of suburban coaches for the Boston & Albany.

The Great Northern Railway has ordered 50 refrigerator express cars from the Siems Stemble Company.

The Bessemer & Lake Erie Railway contemplates buying a number of cars of various types for passenger service in the near future.

Buildings and Structures

The Louisville & Nashville Railroad plans the construction of shops, a roundhouse and terminal facilities at Leewood, Tenn., to cost approximately $500,000.

The Pennsylvania Railroad plans the construction of its shops and roundhouse at Valparaiso, Ind., recently destroyed by fire.

The Atchison, Topeka & Santa Fe Railway has awarded a contract to Joseph E. Nelson & Son Co., Chicago, Ill., covering the construction of foundations and engine pits for its new machine shops at San Bernardino, Calif.

The International-Great Northern Railway will construct a roundhouse with repair shop at San Antonio, Texas, to cost approximately $100,000.

The Florida East Coast Railway is reported to have selected a site, Bowden, Fla., for erection of new locomotive repair shops to replace the present shops at Jacksonville, Fla.

The Chicago, Burlington & Quincy Railroad plans the construction of an addition to the roundhouse and extensions to the yard at Gibson, Nebr., at estimated cost of $170,000.

The Wabash Railway is preparing plans covering the rebuilding of its car shops at Decatur, Ill., recently destroyed by fire.

The Atchison, Topeka & Santa Fe Railway is preparing plans covering the construction of shops at Richmond, Calif.

The Missouri Pacific Railroad will rebuild its machine shop and power house at Monroe, La., which was recently damaged by fire with a loss of $100,000.

The New York, Chicago & St. Louis Railroad is preparing plans covering the construction of a one-story machine shop at Conneaut, Ohio.

The Baltimore & Ohio Railroad is receiving bids for a large water treating plant to be installed at Connellsville, Pa.

The Chicago, Burlington & Quincy Railroad will erect a steel car repair plant at Galesburg, Ill., estimated to cost $200,000.

The New York, Chicago & St. Louis Railroad plans the construction of an addition to its roundhouse at Sharonville, Ohio.

The Pennsylvania Railroad plans the construction of an enginehouse and repair shops at Harrisburg, Pa., estimated to cost $200,000.

The Southern Railway is preparing plans for the construction of a 37-stall roundhouse at Spencer, N. C., also an engine shop, a turntable and two engine inspection pits at the same place.

The Union Railway will rebuild its shop at Memphis, Tenn., recently destroyed by fire at a loss of $30,000.

The Chesapeake & Ohio Railway is reported to be planning extension to the roundhouse, a new erecting shop, an extension to the locomotive shop, two new machine shops, a new boiler shop, a passenger car shop, a paint shop, a truck shop and a water treating plant at Huntington, W. Va.

The Cleveland, Cincinnati, Chicago & St. Louis Railway contemplates the construction of an engine terminal at Cincinnati, Ohio, but has not yet completed plans.

The Wabash Railway plans the construction jointly with the Canadian National of a roundhouse and locomotive repair shops at St. Thomas, Ont., Canada.

The Northern Pacific Railway plans an extension to its repair shops at Livingston, Mont., at estimated cost of $300,000.

The Baltimore & Ohio Railroad has awarded a contract to the Chicago Bridge & Iron Works for furnishing and erecting a water softening tank at Connellsville, Pa., of 547,000 gal. capacity.

The Canadian National Railways plans the construction of a 14-stall addition to its roundhouse at Stratford, Ont., for the accommodation of the larger locomotives.

Items of Personal Interest

H. A. Sigwart has been appointed supervisor of car repairs for the Missouri Pacific Railroad. Mr. Sigwart was formerly traveling mechanical inspector for the Illinois Central Railroad with headquarters at Memphis, Tenn.

E. R. Larson, formerly general foreman of the Delaware, Lackawanna & Western with headquarters at Kingsland, N. J., has been appointed shop superintendent of the Bellmead shops of the Missouri-Kansas-Texas Railroad with headquarters at Waco, Tex.

J. W. Tenney has been appointed road foreman of equipment of the Chicago, Rock Island & Pacific Railway with headquarters at Fairbury, Nebr.

A. W. Fisher has been appointed general foreman car department of the Baltimore & Ohio Railroad, with headquarters at Sandusky, Ohio, succeeding **F. J. Cheshire.**

John Benzies has been appointed road foreman of equipment of the Chicago, Rock Island & Pacific Railway with headquarters at Goodland, Ky.

W. H. Fetner, formerly assistant to president of the Missouri Pacific Railroad has been appointed chief mechanical officer of the road. Mr. Fetner was formerly general superintendent of motive power of the Central of Georgia Railway.

F. J. Cheshire has been appointed general foreman of car department of the Baltimore & Ohio Railroad with headquarters at South Chicago, Ill.

H. K. Lowry has resigned as signal engineer of the Chicago, Rock Island & Pacific Railway to become associated with the Sprague Automatic Train Control.

H. K. LeSure, chief electrician of the Eastern Region of the Pennsylvania Railroad has been appointed master mechanic of the New York Terminal of the Pennsylvania.

J. W. Lemon, master mechanic on the Missouri Pacific Railroad, with headquarters at Hoisington, Kansas, has been promoted to superintendent of shops at Sedalia, Mo., succeeding **J. P. Brown**, who was promoted to assistant mechanical superintendent.

O. E. Hallberg, assistant superintendent of car service of the Chicago & North Western Railway with headquarters at Chicago, Ill., has been promoted to superintendent of car service with the same headquarters, succeeding **W. D. Beck. G. C. Boomer** has been promoted to assistant superintendent of car service succeeding Mr. Hallberg.

F. R. Forest of the Norfolk & Western Railway has been appointed general foreman with headquarters at Bluefield, W. Va., succeeding **Mr. Veazey**, transferred to Columbus, Ohio.

W. J. Bergen, valuation engineer of the Nickel Plate Road was appointed chief engineer, in addition to his present duties. **E. E. Hart** was appointed consulting engineer.

The position of supervisor of locomotive operation on the Marion and Chicago divisions of Erie Railroad has been abolished.

J. E. Symons, who was many years a master mechanic on the Atchison, Topeka and Santa Fe Railway and more recently superintendent of the mechanical expert department of the Railway Traffic and Sales Division of the **Texas Company** has joined the mechanical department of the New York, New Haven & Hartford Railroad with headquarters at New Haven, Conn.

R. V. Carleton has been appointed division master mechanic of the Brownsville Division of the Canadian Pacific with headquarters at Brownsville Junction, Me.

Supply Trade Notes

The Clark Car Company, Pittsburgh, Pa., has removed its New York office from the Woolworth Building to 52 Vanderbilt Avenue, New York City. **B. K. Mould**, district sales manager is in charge.

The Graver Corporation has moved its railroad office from 1412 Steger Building, Chicago, Ill., to the main office and works at East Chicago, Ind., and will retain its office in Chicago as a branch sales office. **J. J. Felsecker** will have charge of the railroad department succeeding **W. R. Toppan**, resigned.

Westinghouse Air Brake Co. has awarded contract to **Stone and Webster, Inc.**, for the construction of its new foundry and machine shop at Wilmerding, Pa.

William R. Hillary has been appointed sales engineer of the **National Lock Washer Co.**, with headquarters at the home office, Newark, N. J.

The Air Reduction Co., New York City, is planning an expansion program for the present year, which will include the erection of new plants at Lima, Ohio, and Harrisburg, Pa.

Thomas S. Gates of **Drexel & Co.**, Philadelphia, Pa., has been elected chairman of the board of directors of the Baldwin Locomotive Works.

The Erie Steam Shovel Company is preparing plans for the construction of a one-story factory at Cleveland, Ohio.

H. K. Lowry, formerly signal engineer of the Chicago, Rock Island & Pacific Railway has become associated with the **Sprague Automatic Train Control.**

T. F. Manville, formerly president and treasurer of **Johns-Manville, Inc.**, has been elected chairman of the board and chairman of the executive committee. **H. E. Manville**, formerly vice-president and secretary, succeeds Mr. Manville as president. **L. R. Hoff**, formerly sales manager has been appointed vice-president and general manager of the factories. **J. E. Meek, J. W. Perry,** and **J. S. Carroll** have been elected vice-presidents; **A. C. Hoyt**, secretary and treasurer, and **T. F. Manville, Jr.**, assistant secretary and treasurer.

The Linde Air Products Co., has let contract to **J. W. Cowper Co.**, Buffalo, N. Y., covering the construction of a one-story addition to their factory at Buffalo, N. Y., estimated to cost $25,000.

Clinton S. Smith has been appointed personnel manager of the **Westinghouse Electric Products Co.**, Mansfield, Ohio. Mr. Smith was formerly connected with **Manning, Maxwell & Moore**, at Bridgeport, Conn.

H. S. Brautigam, assistant to the master car builder of the Chicago, Milwaukee & St. Paul Railway has resigned to become a representative of the railroad department of the **Allegheny Steel Company**, Brackenridge, Pa.

J. F. Ryan, district manager of the **Texas Company**, with headquarters at New York, has been transferred to Chicago, Ill., with headquarters in the McCormick Building, succeeding **W. H. Noble** who has been transferred to Houston, Texas. **W. E. Greenwood**, assistant manager with headquarters at New York, will have charge of railroad sales in that territory.

The Buckeye Steel Castings Co., has awarded contract covering a considerable addition to its foundry at Columbus, Ohio.

R. C. Shaal, president of the **R. C. Shaal Company**, New York, N. Y., formerly vice-president of the **Safety Car Heating & Lighting Co.** is now associated with the **Standard Stoker Company, Inc.**, at New York, in special sales work. Mr. Shaal will continue as president of the R. C. Shaal Company.

The Linde Air Products Co., New York City, announces the following changes in its sales department; **Robert W. White**, formerly general sales manager has been appointed general sales manager of the Carbide & Carbon Chemicals Corp.; **L. M. Zimmer**, western sales manager of the Linde Company has been appointed assistant general sales manager to succeed Mr. White; **Herman Ullmer** has been appointed assistant sales manager, western division, Chicago, Ill., and **F. E. Stoppenback** has been appointed district sales manager of the New York district.

J. L. Phillips, manager of the Atlantic office of the **Okonite Company** has been transferred to San Francisco as manager of the San Francisco office.

The Ward Railway Equipment Company, Lima, Ohio, has been incorporated to manufacture miscellaneous equipment for railroads. The incorporators are: **O. G. Snyder, Edward P. Kirly, George T. Shanbow, B. E. Parish, J. T. Ward, Charles Erskick** and **J. B. Rowntree.**

Joseph W. Irwin has resigned as superintendent of the **Fort Pitt Spring & Manufacturing Co.**, Pittsburgh, Pa., to take effect March 31st. Mr. Irwin has resigned to take the position of vice-president and general superintendent of the **Mitchell Spring & Manufacturing Co., Inc.**, Johnstown, Pa.

Edward F. Wickwire for several years secretary of the **Ohio Brass Company**, Mansfield, Ohio, was recently made vice-president of the company. Mr. Wickwire became identified with the Ohio Brass Company in 1903.

The Wilson Welder & Metal Co., 132 Kind Street, New York City, has leased space in the Manufacturers Terminal Building, Hoboken, N. J.

The Ohio Machine Tool Co., Kenton, Ohio, manufacturers of shapers, has appointed the Dale Machinery Company its exclusive representative in the Chicago district. The latter company has also recently opened office at 50 Church St., New York, N. Y.

The Long Bell Lumber Company is erecting what is planned to be the largest lumber manufacturing plant in the world at Longview, Wash., to be ready for operation in the summer of 1924. This company after many years of manufacturing in the pine districts of the south will at that time transfer its operation to the Pacific Northwest, and for the first time in forty-eight years of its history will be definitely placed in the Douglas Fir market.

The Bulldog Automatic Coupler Company, Pikesville, Ky., has been incorporated with the following officers: **A. J. Balewin,** president; **Charles D. Jacobs,** vice-president and **A. L. Nunnery,** secretary and treasurer.

The Morton Manufacturing Company announces the appointment of the Consolidated Equipment Company with offices at 260 St. James St., Montreal, as exclusive and direct representatives, covering the sale of their line of railway appliances, throughout the entire dominion of Canada.

J. H. Hackenburg, formerly of the **Lake Erie Rubber Company,** Cleveland, Ohio, has been appointed purchasing agent of the **Illinois Car & Manufacturing Co.,** with headquarters at Hammond, Ind.

Obituary

Alfred H. Smith, president of the New York Central Lines, was killed in Central Park, New York, on March 8, by being thrown from a horse which had become disturbed by another horse. In his untimely death this country loses one of its ablest railway executives. Mr. Smith was born in Cleveland, Ohio, in 1864, and from the humble position of messenger boy in 1879 for the Lake Shore and Michigan Southern, he rose gradually to the head of the greatest railway systems in the world. In October, 1890, he was made superintendent of the Kalamazoo division after having served in the bridge and building department. After filling various divisions as superintendent, he was made assistant general superintendent on April 1, 1901, office at Cleveland and on the following June he was made general superintendent, which position he held till February, 1902, when he was made general superintendent of the New York Central & Hudson River, and on July 1, 1903, became general manager and from June, 1906, to April 15, 1912, vice-president and general manager; April 15, 1912, to March, 1913, vice-president of the New York Central Lines, east and west of Buffalo, N. Y.; March, 1913, to January, 1914, senior vice-president, in charge of operation, maintenance and construction. On January 1, 1914, Mr. Smith was elected president of the New York Central System.

Harry Wanamaker, district superintendent of motive power of the New York Central, with headquarters at Albany, N. Y., died on March 23 at Elkhart, Ind. Mr. Wanamaker was born on August 5, 1866, at Pottsville, Pa. He received a high school education and began railroad work on August 1, 1884, with the Philadelphia & Reading as a machinist's apprentice. He was promoted to machinist in 1888 and served in that capacity until 1896, when he was appointed gang foreman at Reading, Pa. He left the Philadelphia & Reading in March, 1900, to become a foreman in the erecting shops of the New York Central at West Albany, N. Y., where he remained until 1905, when he was transferred to Depew, N. Y., as general foreman. On January 1, 1912, he was appointed superintendent of shops, with the same headquarters, and was transferred to West Albany on May 20, 1912. On July 1, 1920, he was promoted to district superintendent of motive power at Albany, and on September 1, 1922, he was appointed assistant superintendent of motive power. On December 10, 1923, Mr. Wanamaker was appointed district superintendent of motive power, with the same headquarters.

New Publications

Books, Bulletins, Catalogues, Etc.

Postal Car Lighting is the title of a new edition of a catalog descriptive of the equipment of the Safety Car Heating & Lighting Company, New Haven, Conn., for the lighting of postal cars. It describes conduit, wiring and fixture installations which conform to post-office department specifications and it is distinctive in publications of its kind in that it is, in reality, a text-book on the subject of postal car lighting. It contains 77 pages and is profusely illustrated. It contains post-office department specifications on lighting, descriptions of electric and gas lighting equipment and layouts for 70-ft. and 60-ft. mail cars, and for 30-ft. and 15-ft. mail apartments.

Standardization—What It Is Doing for Industry, is a small but interesting book that has just been issued by the American Engineering Standards Committee, 29 West 30th Street, New York. This describes how standardization is being carried on: first, in the individual plant; second, in industry as a whole; third, nationally on an inter-industrial basis; fourth and last, internationally.

This book can be had by writing to the office of the Committee.

Arc Welding Machines and Accessories. Geo. A. Post Co., Inc., 136 Liberty Street, New York City, has issued a new publication on arc welding machines, metals and accessories for railroad service. This company has for several years been the distributor in the railroad locomotive and car building field of the products of the Wilson Welder & Metals Co. The equipment and material described in the publication are especially adapted for that service.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XXXXVII | 114 Liberty Street, New York, May, 1924 | No. 5

An Engine Terminal at Acca, Virginia

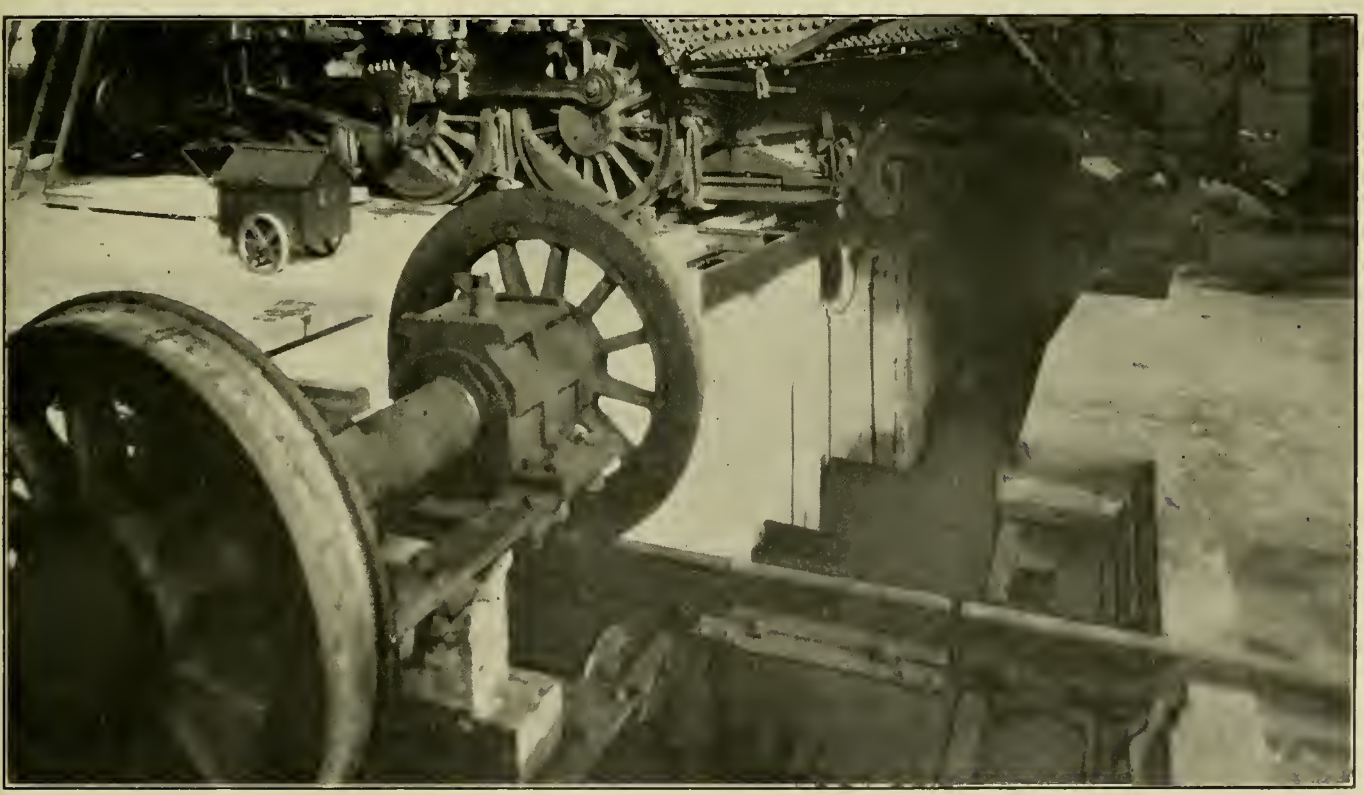
A New Plant of the Richmond, Fredericksburg & Potomac Railroad Containing a Number of Interesting Features

It is not long since the Richmond, Fredericksburg & Potomac R. R. opened its new Union passenger station on Broad street, Richmond, Va., and now it has built a model engine terminal about a mile and a half beyond the station and outside the city limits. And this is but the beginning of a much larger development for which the plans are already made. This further development includes the erection of locomotive and car repair shops of ample size to care for present requirements with provision for such future extensions as may be required. And for this a large property has been acquired.

The present terminal has the usual facilities for dumping, coaling, watering, sanding, turning and housing the locomotives.

Out near the ashpit, where the fires are dumped there is an inspector's house, and inspection pits.

Entrance to these pits is obtained through a tunnel from the inspector's office so that the men are not obliged to climb down between the tender and locomotive in order to go beneath them.



Wheel Drop Pit Showing Trailer Wheels Removed and Lifted for Transfer to Machine Shop

It is in this office that the engineer, on coming in from a run, makes out his report of work to be done, and this together with that found by the inspectors is sent to the foreman of the roundhouse through a pneumatic tube. As it takes from twenty to twenty-five minutes to move the engine over the ashpits, take coal, water and sand and reach the roundhouse; the foreman has ample time to go over the work reports before it arrives, assign it to the most convenient pit for the work to be done; make out his individual work slips and get things ready so that there need be no delay in starting after the engine is in the house.

There are two ashpits each about 250 ft. long and 4 ft. deep. They are lined with paving brick and are kept flooded with about 18-in. of water. They are spanned by a traveling crane, and between them is a third track upon which cars may be placed to be loaded by the traveling crane from which a bucket dredge is operated.

This third track is also fitted with a short ashpit over which the switching engines are dumped and to which they can be run without interfering with the regular movement of the road engines towards the roundhouse. There is also a shallow dry ashpit in the outbound track so that the ashes of engines, that have been standing for a time in or outside the roundhouse can be stopped for the cleaning of their ashpans on their way to the trains without obstructing the regular inbound movement.

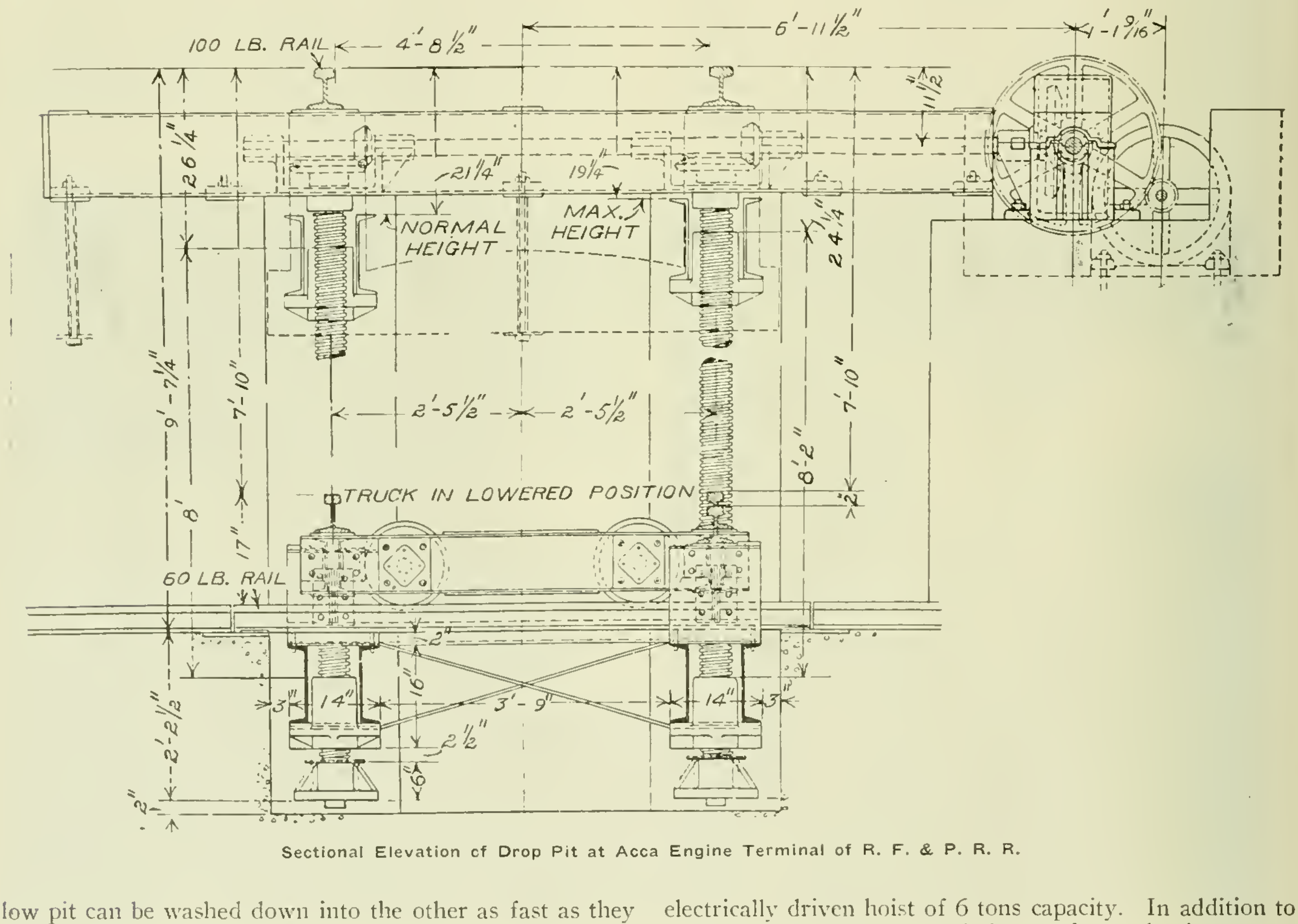
This pit is 12 ft. long and is connected by an underground passage to a deeper pit of the same size under the next ashpit track. This underground passage is sloped sharply downward and ashes dropped in the shallow pit can be washed down into the other as fast as they fall by four jets of water that issue under a considerable pressure from pipes located in the side wall of the pit.

Between the ashpits and the turntable there is a concrete coaling station with a storage capacity of 1,000 tons. The hoppers at the chutes are carried on rapid-weighing scales so that all coal issued to the locomotives is weighed, and an account kept with each individual machine.

The turntable is 105 ft. long and is of the continuous type, that is there are two spans with a flexible connection between them at the center. These are carried, at their ends, by the wheels on the ring rail, and at the center by a regular step bearing. So that if the table were to be uniformly loaded from end to end, the center bearing would carry one-half of the load, and the other half would be carried by the wheels at the ends.

As a matter of fact the table is rarely, if ever, uniformly loaded. The end wheels are always down on the rails and there is sufficient load upon them at all times to make it possible to operate the table. Besides with this construction no balancing is necessary. Simply get the wheels on the table and it can be moved. The result is that it is estimated that this feature makes it possible to turn as long an engine on this 105-ft. table as could be done on one 135 ft. long that required balancing before it could be moved.

The roundhouse may be taken as a model both as regards construction and convenience of arrangement. It is of the usual circular form with an inner circle 267 ft. 4 in. in diameter. This places the face of the house 81 ft. 2 in. from the turntable, and then the house itself has a depth of 110 ft. The circle is so divided as to provide, when finished, for 56 stalls, of which 30 are now completed. Each stall is provided with a pit 84 ft. long. And around the outside of them there is a monorail with an electrically driven hoist of 6 tons capacity. In addition to this there are two monorail beams for each pit, one on each side with a capacity of 1 ton each.



Sectional Elevation of Drop Pit at Acca Engine Terminal of R. F. & P. R. R.

The roof construction of the house is of special interest because of the effect that it has on the condition of the air of the whole interior.

It is in what amounts to four bays. There is first an upward slope from the outer wall towards the center, to the vertical use of the monitor windows. Then a downward slope followed by an upward one to the top of the inner monitor and the vertical face in which other windows are located; then a downward slope to the inner wall. This arrangement forms a trough running about the building. In the outer bay there is the usual smoke jack for each stall

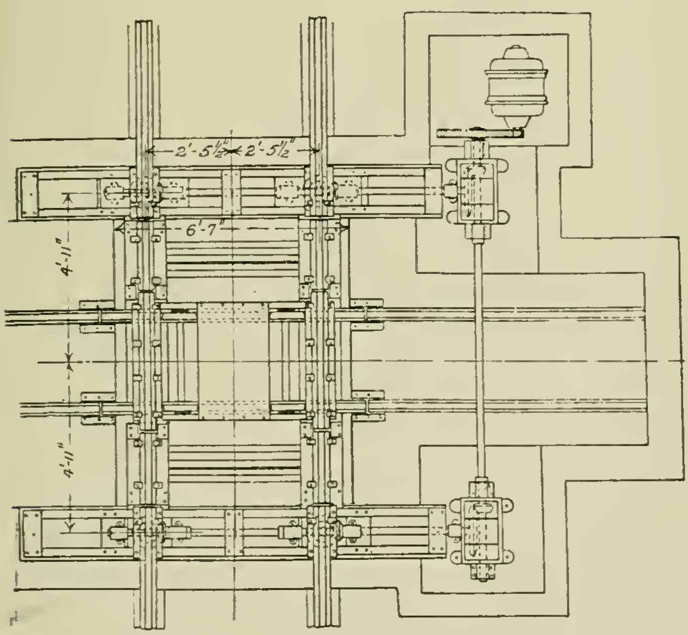
The roof construction is of hollow tile and concrete, the combination being about 4 in. thick. A valuable peculiarity of this roof is that the interior surface is smooth and that all of the supporting beams and girders are radial so that there is no chance for any gases to become pocketed behind a beam and thus remain stagnant to befoul the atmosphere. There is nothing to prevent any gas or vapor rising from an engine, to flow along the lower surface of the roof to the openings in the monitor and thence into the outer air. The result is that, though the building may be filled, the air is clear and odorless.

Among the details of the equipment of the roundhouse the drop pit for the removal of wheels from the locomotives is especially deserving of attention. It was installed by the National Boiler Washing Company of Chicago.

The drop pits are of the type that has been in common use in the United States for many years, the novelty consisting in the details of their arrangement and construction.

Broadly speaking they consist of short lengths of rails that may be raised to a level with the running rails and then, when the wheels, to be removed, have been cast free, they can be lowered with those wheels and run off laterally to clear the locomotive and again raised to the floor level for the removal of the wheels to the point where work is to be done upon them.

The rails weigh 100 lbs. to the yard and are of the American Society of Civil Engineers standard section. They are 4 ft. long and rest upon a truck frame built up of 9 in. channels which is carried on four 12-in. wheels,



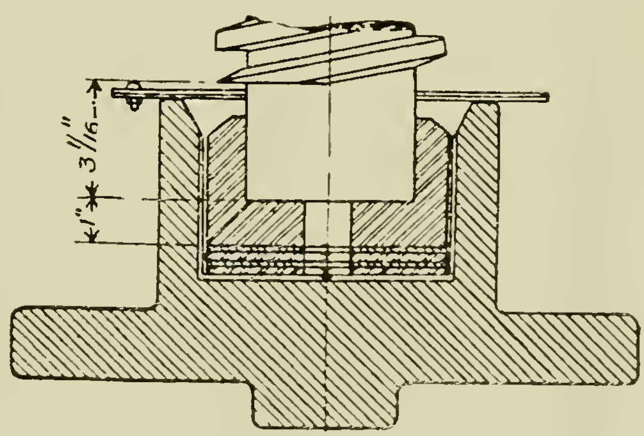
Plan of National Drop Pit Equipment

then run out on a lateral track for the removal of the wheels.

The whole truck is raised by means of four screws located at the corners. These screws are 5 in. in diameter and have a 1 in. pitch. They are driven at a speed of 14.4 revolutions per minute, and are capable of giving the nuts a maximum travel of 8 ft. 2 in. Of this 8 ft. is required to raise the elevating rails to the level of the running rail. The other 2 in. of lift makes it possible to raise the driving wheels above their normal position and so compress the springs of the locomotive that the spring hangers or equalizing beams can be blocked while the springs are so compressed; and then after these table rails have been lowered to the running rail level again, the springs can be removed.

The screws are set 4 ft. 11 in. apart from center to center in one direction and 9 ft. 10 in. in the other so that they stand immediately below the center of the heads of the running rails and outside the ends of the drop pit rails. Their nuts are of phosphor bronze and have a length of thread of 11 in. or a little more than twice the diameter of the screw; and are tied together beneath the rails by two 12-in. channels on each side, and across the rails by two 15-in. I beams on each side. Each of these pairs of I beams carry two short lengths of running rails each 2 ft. long. These are so placed that, when the table and truck are in their upper position, there is a gap of 7/16 in. between them and the rails on truck, and 7/16 in. between them and the pit rails, so that when the table is lowered there is a gap of 8 ft. 4 in. between the pit rails, which leaves ample clearance for the wheels left in place on either side of the pair that has been removed.

The screws rest in cast iron step bearings that are bored out to a diameter of 5 1/32 in. Into this space a forged steel thrust collar is dropped, on the top of four washers all of which are floating. At the bottom there is a steel thrust washer ¼ in. thick, in both faces of which there are cut oil grooves at right angles to each other 1/16 in. deep and ¼ in. wide. On top of this there is a plain phosphor bronze thrust washer ⅛ in. thick; then another steel washer similar to the one below, followed by a second

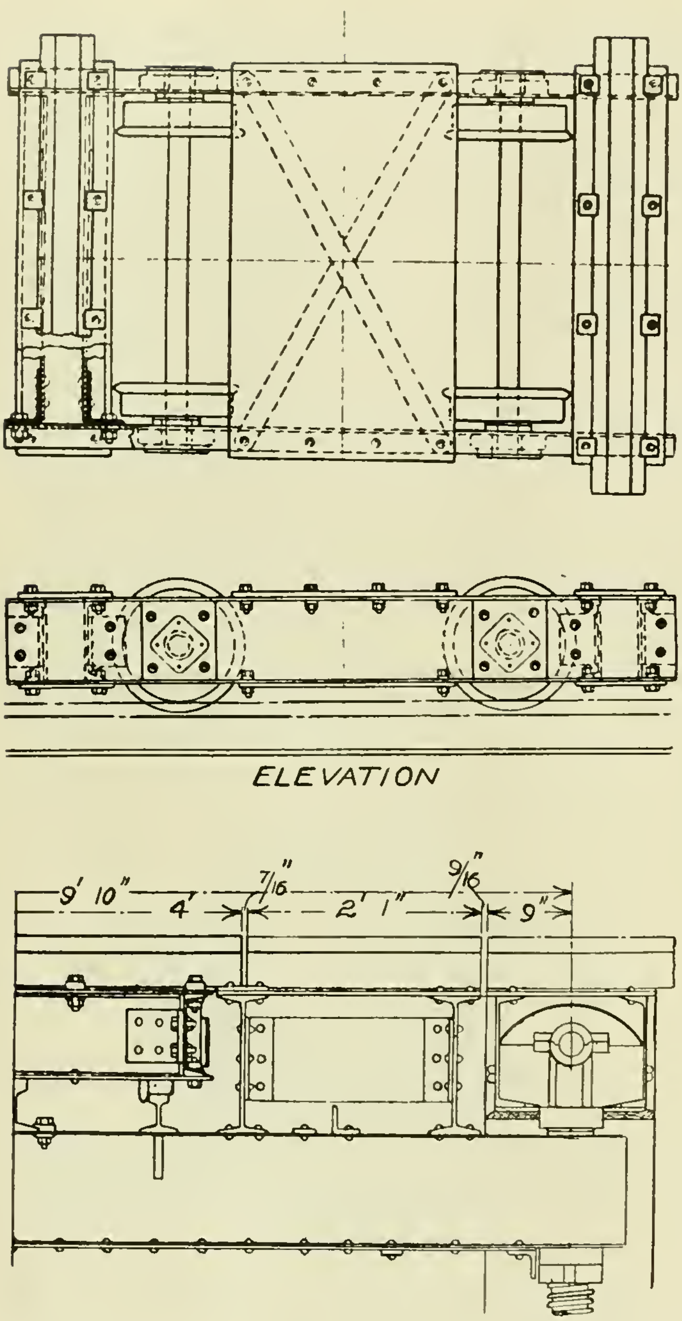


Step Bearing Assembly at Bottom of Screw, National Drop Pit

of phosphor bronze and finally the thrust collar already mentioned. This latter is bored out to a diameter of 3 17/64 in. or 1/64 in. larger than the end of the screw. The whole rests on the concrete foundation of the pit.

The journal at the upper end of the screw is 4 in. in diameter and runs in a phosphor bronze bushing bored with a clearance of .0035 in. Above this, the screw center is turned to a diameter of 3¼ in. and cut with a keyway for the reception of the driving gear.

The screws are driven by a 10 horsepower motor running at a speed of 450 revolutions per minute. This is geared down by means of spur and level gearing so as to give a rotation of 14.4 revolutions per minute at the screws which, in time, makes it possible to raise or lower the table through the whole height of its normal lift in a little more than 6½ minutes. This operation is controlled by a push button switch mounted on one of the columns adjacent to the pit. With this arrangement it is possible to control the movement of the table either up or down within a small fraction of an inch and its speed in either direction is always uniform.



Assembly of Truck With Elevation of Table, National Drop Pit

There are two of these drop tables in the new engine house at Acca serving tracks adjacent to the machine shop. With this installation, the wheels are removed from the pit and conveyed to the machine shop by means of a monorail hoist and transfer system. The mechanism for these drop tables was all assembled in the factory before being shipped to Acca and given an actual working test with a load largely exceeding the weights that will be encountered in service.

Another detail of great interest is the boiler washing plant that was installed by the National Boiler Washing Co. of Chicago.

This plant, the pumps and some of the piping of which are shown in the illustration, does a number of things automatically, which it is very desirable to accomplish.

The fundamental feature of it is that it saves nearly all of the water and heat contained in a boiler that is being blown off, and utilizes it for washing or filling purposes.

It is known, though not perhaps as widely as it ought to be, that water subjected to concentration by boiling and evaporation at a high pressure and temperature, undergoes chemical changes, so far as the impurities held in solution are concerned, that are sometimes quite startling in their magnitude. These changes may be such that they will have a very detrimental effect upon the metal of the boiler. They are not of much importance when low pressures and temperatures only are concerned, but when steam pressures of 200 lb. per sq. in. and temperatures in the neighborhood of 400° Fahr. are involved, with a possible concentration of from 75 to 100 to one, it is well to guard against them.

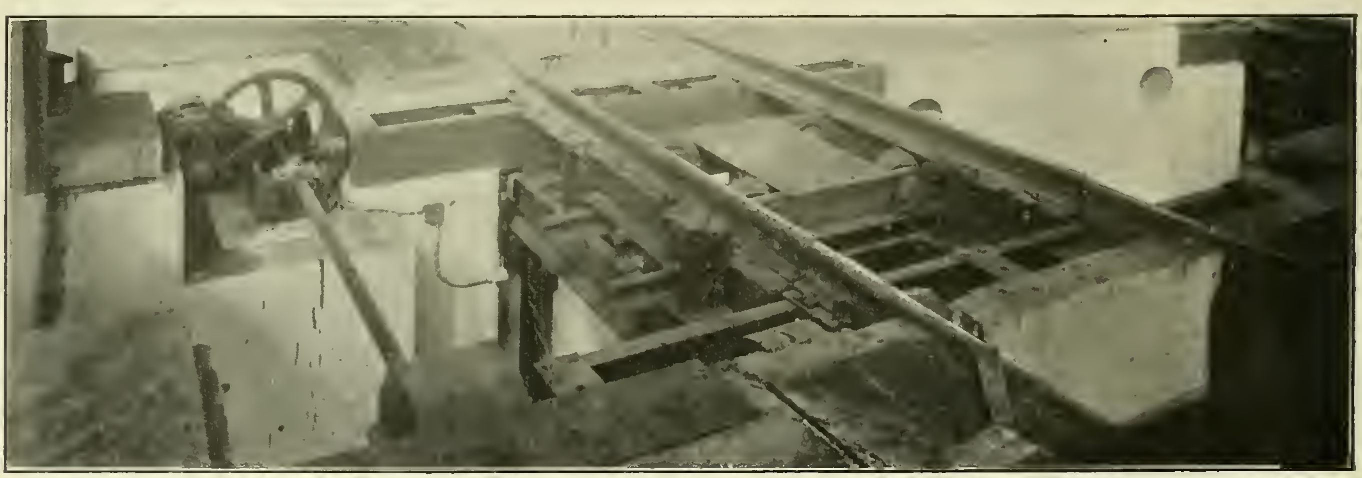
This is exactly what is done by this boiler washing plant.

The hot water coming from the boiler, being blown off, is led into a tank from which it is drawn for washing purposes only, and eventually finds its way to the sewer where it belongs. At the same time the steam arising from this blown-off water, is caught and made to heat fresh, raw water that is used for refilling the boilers after they have been washed out; so that each boiler starts out with fresh hot water, that has been subjected to no concentration and no chemical change of the impurities which it may chance to hold in solution.

All this is done automatically by a very simple arrangement of properly co-ordinated apparatus.

The illustration of the pump room shows the arrangement of the piping and valves by which these results are attained.

When a boiler is being blown off the escaping water and steam is discharged into the side of a sludge tank the bottom of which just appears at *A* in the engraving. This

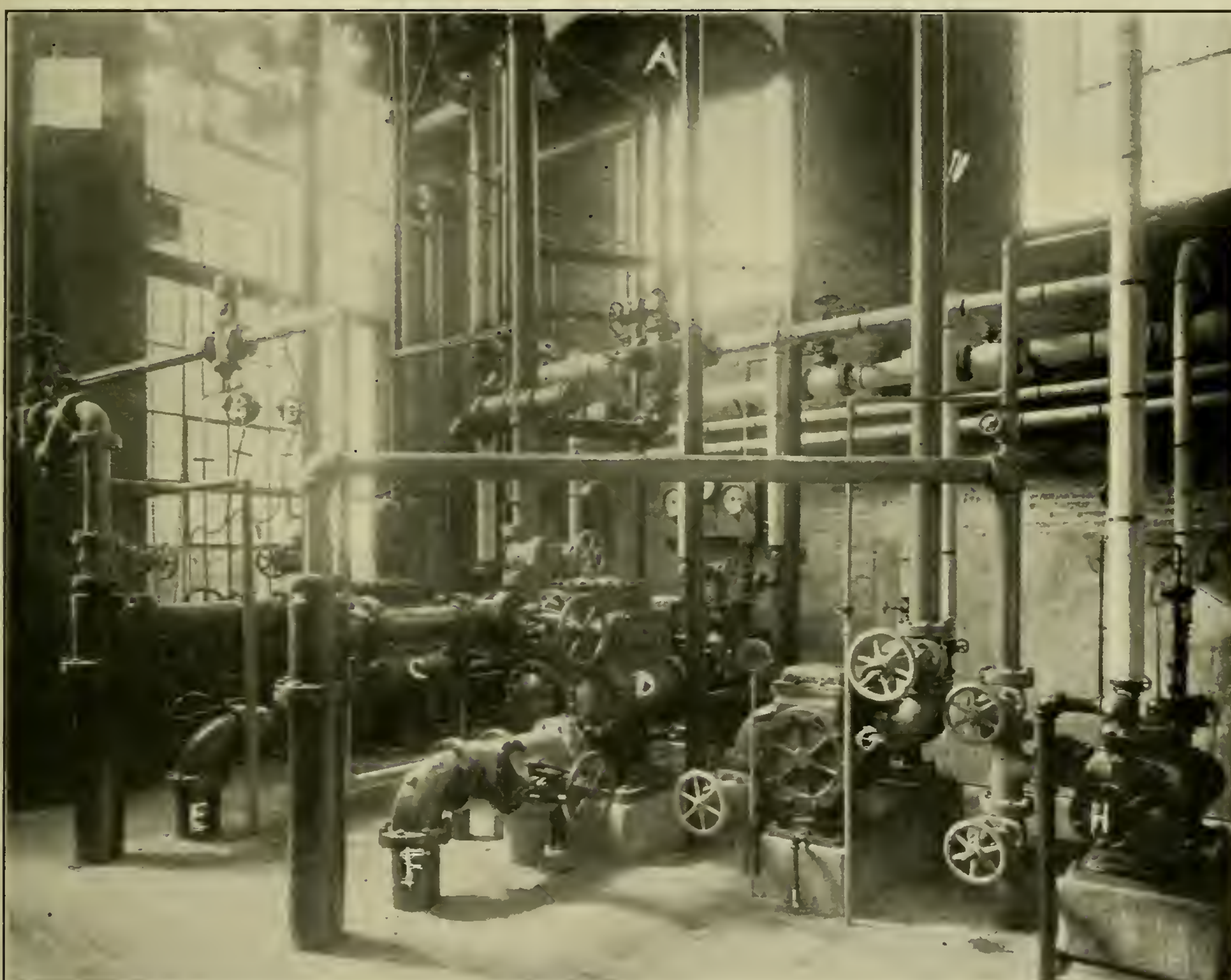


Drop Pit With Covers Removed Showing National Drop Table tank is 60 in. in diameter, 72 in. long and is made of ¼-in. steel. It will be noticed that there is a pipe leading downward from the center of the bottom. This pipe is normally open and leads to the sewer. So that the first inflow of water from the boiler being blown off, flows directly through the sludge tank and out of this pipe to the sewer. It is possible that 300 gallons or so are lost in this way and that is all. This first flow, it should be borne in mind, usually contains a heavy surcharge of sediment, that it is well to get out of the way.

This vertical waste pipe, however, contains a shut-off valve controlled by a thermostat, and when this thermostat is raised by the outrush of hot water to a temperature of 180° Fahr. it closes the valve in the waste pipe and the sludge tank starts to fill. When the water level has risen to a point about 2 ft. above the bottom, the hot water flows out through a side opening to a pipe leading to the filling the upper part of the sludge tank. It flows out through a pipe located near the top and into a condenser tank and on its way encounters a thermostat. This opens a valve and permits an injection of cold water from the city mains to enter and condense the steam. The water thus injected and heated by the steam flows out at the other side and, if its temperature is above 180° Fahr., another thermostat opens another valve and enough more city water is injected to reduce the temperature to 180° Fahr. and this water flows by gravity into the storage tank for filling water, which also has a capacity of 25,000 gallons.

In addition to getting the water into the tanks it is quite as necessary to control its level and prevent an overflow. The maximum permissible depth of water is about 14 ft.

It will be noticed in the engraving that there are two



National Boiler Washing Plant at Acca Terminal of R. F. & P. R. R. Showing Valves, Pumps and Piping.

storage tank for washout water located outside the building.

But the temperature is too high for washout purposes and in this pipe there is another valve controlled by a thermostat, which, when heated, opens a valve permitting an inflow of city water to mingle with the hot discharge until the mixture has a temperature of about 130° and this is delivered to the tank for the storage of washout water, which has a capacity of 25,000 gallons.

Meanwhile steam is rising from the blow-off water and balls *B B* suspended from rods running upward. These balls are connected to the two tanks respectively and are normally full of water. Other balls higher up are connected to the upper parts of the tank and are filled when the water level approaches its upper level. When these balls fill, they empty the lower ones and open a valve to the waste so that no more water is delivered to the tanks until the level pulls and they are drained back into it.

The two pumps *C* and *D* at the left of the engraving are the pumps used for washing out and filling the boilers, and can be converted to fire pumps by closing the valves in the pipes leading to the tanks and opening those leading to the city water mains which rise through the floor at *E* and *F*.

The pump *G* is a vacuum pump which takes the water of condensation from the heater coils of the indirect heating system and puts it into the storage tank for the feed water. And the pump *H* is the boiler feed pump.

The piping is painted in various colors to indicate the purposes for which it is intended, so that the course of

Inspection Runway in Gallery of Boiler Washing Plant

the flow of the different waters can be easily followed. For example:

The live steam pipes are white and the exhaust yellow, while the air pipes are grey.

The low pressure water pipes are blue; the boiler feed is green and the fire lines red.

For the boiler washing, the blow-off is orange; the washout blue; the filling green and the sludge black.

Three lines of pipe are led to the roundhouse, and they run along under the roof, with a foot-walk beside them, as shown in the illustration. Then at each alternate row of columns between the pits, there is a blow-off connection, and at the columns between these there are blow-off, washout and filling connections.

Attached to the roundhouse there is a machine shop 177 ft. 4 in. long and 110 ft. 6 in. wide, which is to be equipped with the tools required for work rather heavier than that of the ordinary running repairs.

Thus, taken as a whole, this plant may be regarded as the latest and most advanced development of engine terminal design.

Fuel Committees Act Jointly

At a meeting of the joint committee on fuel conservation of the American Railway Association and a special committee of the International Railway Fuel Association passed on a number of important co-operative measures in relation to the use of fuel oil and coal on various railroads. The meeting was attended by representatives of the operating, mechanical and purchasing departments from railways in all parts of the country, F. H. Hammill, assistant general manager, C. & N. W. Ry., presiding. Besides the regular committee members the meeting was attended by Professor E. C. Schmidt of the University of Illinois and Professor G. A. Young of Purdue University.

The most important action taken by these committees was the approval of a plan for establishing a central agency for the joint investigation and testing of fuel and fuel saving devices. This plan will now be submitted to the board of directors of the American Railway Association for approval and will carry with it the recommendation for the appointment of a research director and corps of assistants.

A definite ratio for equating coal and oil as fuel in consumption and conservation comparisons has been under consideration for some time and at the joint committee meeting a report was approved advocating a definite ratio of fuel oil equivalent to one ton of coal be recommended to the Interstate Commerce Commission for use in the operating statistics submitted by railways using fuel oil. A further study of this subject based upon original investigation and actual tests may be undertaken later with a view to arriving at an accurate equation of the two fuels on various railways. The relative value of coal and oil fuels is one of the problems needing solution which will be submitted to the proposed research director employed by the American Railway Association. This situation has been outlined by the joint committee on fuel conservation as follows:

"During the past few years a growing volume of fuel oil has been substituted for coal on various railroads. Hardly a railroad today is able to say just exactly what the equivalent of 2,000 lbs. of coal, of a certain grade, is, when translated into fuel oil purchased on a gallonage basis, with variations in thermal content, based again upon differences in weight per gallon and percentages of non-combustible matter (water and sediment), which, while running comparatively light in certain oil, is relatively heavy in the case of others. There is, further, but very limited information available as to the measure of loss sustained in heating certain heavy oils to a point where they can be economically consumed.

"This situation has caused certain railroads in the past few years grave concern, with loss of economies that might have been obtained by a more prompt substitution of fuel oil for coal when oil became suddenly available, as usually happens, and with the large mileage now fueled with oil the point at which to let go in the event of a future scarcity of fuel oil will provoke even greater concern, for the reason that in the territory where oil is most heavily consumed, the relative development of coal mines is materially below that which obtains generally throughout the country."

At the meeting in Chicago, the committees decided upon the text of a questionnaire to be submitted to all the railroads for the purpose of determining actual progress toward fuel conservation and what fuel economy practices have been generally adopted. The first three booklets of the American Railway Association's manual on fuel and related economies as compiled by the International Railway Fuel Association were also approved at this meeting and will soon be available for distribution to the railways.

Locomotive Exhibits at Atlantic City

The track exhibits at Atlantic City during the convention of the Mechanical Division of the American Railway Association in June will include two very interesting steam locomotives.

The American Locomotive Company will have on exhibition experimental locomotive No. 5000 which is in service on the Lehigh Valley Railroad. The results of tests of this engine were reported in the April issue of Railway and Locomotive Engineering.

The Delaware & Hudson Company will show the new three-cylinder Consolidation type locomotive now under construction. This engine was designed by Mr. John E. Muhlfeld, and was briefly referred to in the December, 1923, issue of Railway and Locomotive Engineering. This locomotive will carry the unusually high working steam pressure of 350 lb. per sq. in., and is the two cylinder cross compound type.

Economy in Locomotive Fuel Means Efficiency in Locomotive Operation

By W. E. Symons

Notwithstanding the fact that our splendidly built railways are the equal or better managed than any in the world, we find on a close inspection or analysis, that in our wonderful accomplishments in so short a period of time, there is an inviting opportunity to effect economies in certain selected items of expense, and one of these, as has been pointed out in previous articles in RAILWAY & LOCOMOTIVE ENGINEERING, is in the item of locomotive fuel.

Let Us Take Stock of the Situation

The locomotive fuel bill for Class 1 railways last year was approximately $523,724,145.00. Fifteen (15%) per cent saving on this item would be $78,558,621.75. Capitalized at 6% $78,558,621.75 would justify an expenditure of $1,309,310,362.00.

The average pounds of coal per 1,000 ton-miles on 40 of our principal railways last year was 179, while on one of the lines among the highest of the 40, an improved type of freight engine equipped with all modern devices for saving fuel, is handling heavy fast freight trains with less than 70 lbs. of coal per 1,000 ton-miles.

The average pounds of coal per passenger car-mile on these 40 principal trunk lines was 20.4 lbs. while one of the heavy passenger carriers with an average of 14 lbs. per car-mile, recently handled a train of 10 Pullman cars, with one engine without change 916 miles at an average speed of 44 miles per hour, and with a coal consumption of only 7.7 lbs. of coal per passenger car-mile.

The question naturally arises in the mind of any student of railway economies: if the job can be handled with less than half the quantity of fuel now used, *"why permit the waste to continue."* The answer is, first to explain, that in the test runs only fuel used in hauling the trains was included, while in the general averages all fuel purchased for, and charged out to locomotives is included and quite a little is used for firing up, etc., at terminals, or in road delays when engines are *not* producing either *ton-miles* or *car-miles*.

With a liberal allowance for all fuel used when engines are not working steam however, there is still room for much improvement, and one method of attack would be to relieve excessive back pressures on pistons, thus not only reducing the quantity of fuel required for a stated unit of work, but also increase the capacity or efficiency of the engine, thereby securing a *double return* on the slight expense involved.

Standard Front End Arrangements

The American Railway Master Mechanics' Association through its committees, and the mechanical officers of various railways through their own individual efforts and with the co-operation and aid of locomotive builders have made wonderful strides in the development of standard front end arrangements, nozzles, etc., still it may be said that these standards are largely controlled by (a) kind of fuel, (b) type and size of engine and (c) individual preference or ideas of mechanical officers of different lines, so that as a matter of fact the term standard really means:

The arrangement best suited to our fuel, our engines, and our ideas of what is the BEST, and while the writer fully concurs in this plan of development, yet a feature which is thought open to criticism, is one of omission of attention to the matter of *excessive back pressure* on pistons.

Various Designs of Nozzles

A full display of all types, kinds and sizes of nozzles that have been or are now in use, would in some respects resemble a curiosity shop rather than evidence of mechanical skill, for there has been many freak contraptions used, and doubtless many are now in use that are far from perfect, in that they are a factor in creating excessive back pressure on pistons, which materially detracts from the potential capacity and efficiency of the complete power unit.

Improved Nozzle on One of the Trunk Lines

As the result of much study and experiment on one of our largest trunk lines a few years ago an improved type of nozzle was developed and put in use that showed remarkably favorable results as compared to the standard nozzle which had been in general use on that system.

Exhaust Nozzle With Internal Projections

This exhaust nozzle has internal projections from the periphery of a circular opening of the usual type. The projections are of triangular section, four in number; each extends out 1⅛ in. from the periphery of the opening and is 11/16 in. in width at its top face, the area of the nozzle opening being reduced 3.44 sq. in. The projections are fastened in place with studs or permanently fastened by electric welding, so that the apex of each piece points in a downward direction. This makes it impossible to either increase or decrease the size of the opening without breaking off the welded projections and will eliminate the tendency to make unauthorized changes in the size of standard nozzles. In making up a nozzle of this type, it has been the practice to bore the circular nozzle for the particular class of locomotive on which it is to be tried, ¼ of an inch larger than the specified diameter. The projections are then made to give an area equal to the difference between specified and bored out areas. This method reduces the cost of application to a minimum, and does not necessitate the making of a new nozzle.

The purpose of the projections is to break up the continuity of the circular section of the exhaust jet and change it to a "Maltese cross form," thereby increasing the gas entraining capacity of the jet and creating a greater vacuum in the front end. The nozzle is fastened to the exhaust stand without attention to the angular location of the projections relative to the axis of the front end, as experiments have proved that alterations in this location do not affect the performance.

A number of tests were made with locomotives equipped with both the standard circular nozzle and the internal projection nozzle on engines of three classes, in each case the only change made on the locomotive being the change in exhaust nozzles. These engines were of the Atlantic, Pacific, and Mikado types.

The accompanying table gives a comparison of the maximum results which were obtained from the locomotives when using each of the two nozzles. A wide open throttle was used in each instance and the working pressure was 205 lb. per sq. in.

It will be observed that a much better performance in general was obtained from each of the locomotives when using the new type of nozzle, and especially is this true in the case of the Pacific and Mikado type locomotives, both of which have boilers similar in design. The Pacific type locomotive delivered an equivalent evaporation of 87,414 lb. per hour and 3,183.9 indicated horse-power, with the internal projection nozzle, while with the standard 7 in. circular nozzle it was possible to obtain but 51,842 lb. equivalent evaporation per hour and 2,241.5 indicated horse-power The Mikado type locomotive, having smaller drivers and a longer stroke, developed 79,675 lb. equivalent evaporation per hour compared with 58,539 lb. obtained with the circular nozzle, and 2,835.5 indicated horse-power or an increase of 469 indicated horsepower above what was developed with the use of the 7 in. circular nozzle. Comparing the performance of the Atlantic type locomotive when equipped with each of the two nozzles, there was obtained with the four internal projection nozzle an increase in equivalent evaporation of 24.2 per cent and 14.6 per cent greater indicated horse-power.

The considerably higher front end draft obtained with the new type of nozzle in each instance is responsible for the remarkable results, attained, enabling a much greater rate of combustion and a higher degree of superheat to be obtained.

From the foregoing comparisons the following salient points stand out as to percentage of efficiency of the improved type over the plain circular tip or orifice, although both were of the fixed type and could not be altered or adjusted by the engineer, to meet varying conditions of service.

In looking over the performance of engines equipped with the improved device as compared with the plain circular nozzle tip the results in favor of the former expressed in per cent is about as follows:

Horse Power	21.2	42.3	20.2	Aver.	27.9%
Dry coal per S. F. Grate	19.2	137.	40.5	Aver.	65.5%
Draft in Smoke Box	81.8	220.	73.2	Aver.	125.0%
Water Evap. per hour	24.2	63.5	28.8	Aver.	38.8%

With such remarkable results from a nozzle of the fixed unadjustable type, it is safe to assume that many additional advantages could be secured from one of the adjustable or variable type, by which means, among others, five (5) of the most essential features of efficient locomotive operation are brought within control of the engineer in charge of, and operating the engine, namely:

(a) More perfect combustion of, and material reduction in, quantity of fuel used per unit of service performed.

(b) More perfect entrainment of gases, cinders, etc.

(c) Minimum excessive back pressure on pistons.

(d) Minimum maintenance charge to entire unit, and

(e) Maximum potential capacity of engine available for service.

With the foregoing advantages possible of attainment at slight expense, it would seem the field was a most inviting one.

Type of locomotive—	Atlantic		Pacific		Mikado	
Kind of nozzle—	Four Internal Projections	Circular 6.25 in. Diameter	Four Internal Projections	Circular 7 in. Diameter	Four Internal Projections	Circular 7 in. Diameter
Area of nozzle, square inch	30.86	30.68	38.19	38.45	38.08	38.45
Speed miles per hour	46.9	47.0	47.3	37.8	28.3	29.3
Actual cut-off, in per cent	52.0	46.0	60.3	46.4	60.8	51.1
Average boiler pressure lb. per square inch	204.9	184.8	201.3	202.2	204.7	204.4
Draft in smokebox, inches of water	15.1	8.3	18.8	5.7	14.9	8.6
Draft in ashpan, inches of water	0.40	0.41	0.71	0.51	0.60	0.64
Dry coal fired per bour, lb.	8,271	6,942	11,813	5,146	9,312	6,621
Dry coal per square foot grate	148.3	124.4	170.6	74.3	133.0	94.6
Water evaporation per hour, lb.	44,628	35,928	65,400	39,977	59,508	46,170
Equivalent evaporation per hour, lb.	58,641	46,771	87,414	51,842	79,675	58,539
Superheat, degrees Fahrenheit	204.2	175.9	215.2	157.2	183.5	122.2
Indicated horsepower	2,304.8	1,901.1	3,183.9	2,241.5	2,835.5	2,366.7

Increase in Locomotive Mileage, Time in Service and Efficiency

Much has been accomplished during the past year or so in the way of increased locomotive mileage particularly so in the matter of continuous through long runs of passenger engines, still there is room for greater improvement in this same direction, also in the matter of engines out of service, either undergoing or waiting for repairs, to the end that this enormous capital investment be utilized to better advantage.

That the opportunity for improvement in utilizing freight power more advantageously may be more clearly understood, we reproduce below table showing average of train speeds, engine miles per day, and hours actual running time, for 11 months of 1922 and 1923 from I. C. C. reports.

Table compiled from reports of 161 class 1 roads representing 173 lines with a mileage of 234,529. Period covered 11 months of 1922 and 1923.

	1922			1923		
District or Territory	Train Speed	Engine Miles Per Day	Hours Running Only	Train Speed	Engine Miles Per Day	Hours Running Only
New England Region	10.9	50.6	4'.36"	10.2	57.3	5'.36"
Great Lakes Region	11.0	46.5	4'.13"	10.6	58.2	5'.30"
Ohio, Ind. and Alleg. Region	9.9	47.4	4'.47"	9.4	59.1	6'.18"
Total Eastern Dist.	10.4	47.3	4'.30"	9.9	58.5	5'.54"
Pocahontas Region	9.9	48.6	4'.54"	9.8	58.4	4'.55"
Southern Region	11.6	59.3	5'.6"	11.5	70.0	6'.36"
North Western Region	11.6	48.7	4'.9"	11.4	55.1	4'.48"
Central Western Region	12.2	57.3	4'.42"	12.2	66.3	5'.25"
South Western Region	11.5	53.2	4'.37"	11.5	58.5	5'.06"
Total Western Dist.	11.8	53.2	4'.30"	11.8	60.5	5'.07"
United States	11.1	51.3	4'.37"	10.9	60.8	5'.30"

No doubt the figures for the full year of 1923 and 1924 will show improvement, but when we consider the power actually in service with such low mileage and hours, and a relatively high percentage of power entirely out of service undergoing or awaiting repairs, we then have a better measure or estimate of Idle Capital and what it means in American dollars.

Excessive Back Pressure on Pistons vs. Money

In a former issue of this paper it was shown that on one of the big trunk lines the average back pressure on pistons of a number of representative passenger engines ranged from 139 horse-power at 20 miles per hour to 376 horse-power at 50 miles per hour, one engine going as high as 590 horse-power.

The average back pressure on a greater number of freight engines ranged from 164 horse-power at 10 miles per hour to 516 at 25 miles per hour while two of the engines showed back pressure of more than 1,000 horse-power at 25 miles per hour.

With all the data in hand on this matter it would appear that this problem was not one difficult of solution, and that definite plans could be put into operation that would result in favorable results, as this feature is one of the factors contributing to low mileage and high operating costs.

Tentative Plan

Tentative plans may be predicted on the assumption, that with back pressure on pistons as high as 500 horsepower on passenger engines, and above 1,000 on freight engines, we can safely assume that the excessive back pressure which may be eliminated, thus increasing the efficiency of the engine, and saving fuel, will average 100 horse power per engine, working steam an average of 4 hours per day. Taking these figures for estimating purposes, we get the following results:

Number locomotives in U. S.	67,000
Less engines out service for repairs, etc. 20%	13,400
Engines in service approximate........	53,600
Number engines in use per day.........	53,600
Average excessive back pressure on pistons	100 H.P.
Average hours per day working steam....	4 hrs.
Pounds of coal per HP.H..............	4 lbs.
Pounds of coal per day excessive back pressure	85,760,000 lbs.
Tons of coal per day excessive back pressure	42,880 tons
Expense per day with coal at $4.00 per ton	$171,520.00
Expense per year of 310 days only at $4.00 per ton	$53,171,200.00

These figures are purposely made very conservative and are of course entirely too low to fit thousands of cases in every day practice, such as engines on runs with more than 150 HP. excessive back pressure, burning coal at $4.50 to $5.00 per ton and working steam 6 to 8 hours per day, 365 days per year, in which case the possible fuel savings on that one run alone in one year, would be about $3,449.24, and to this must be added the increased efficiency of the complete locomotive, and decreased cost of repairs per unit of service, which in many cases would be far in excess of the money value of fuel saved.

It is an inviting field for railway officers and the practical railway engineer experienced in the solution of such problems.

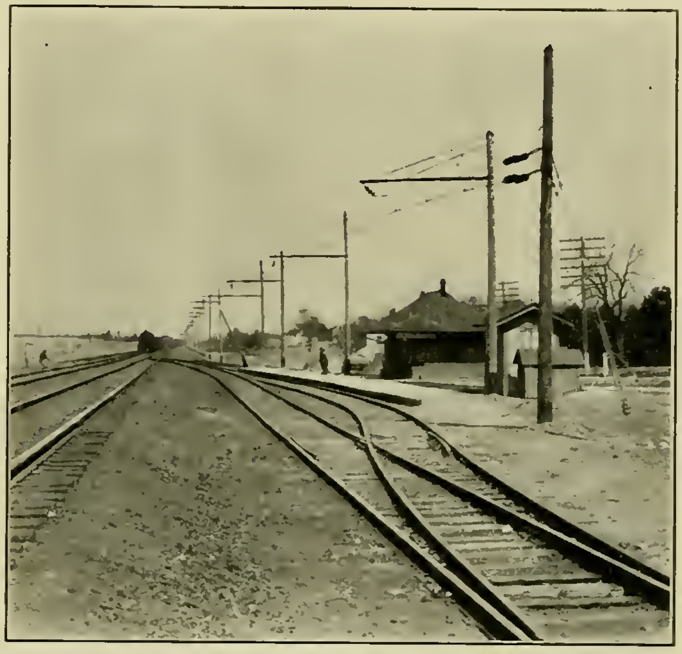
Electrification of Branch of Pennsylvania Railroad

An interesting development in railroad electrification, showing the flexibility of the 11,000-volt A.C. system, is the recent electrification of the Fort Washington Branch of the Pennsylvania Railroad System, operated electrically since February 27, 1924. This single track branch extends from Allen Lane Station, on the Chestnut Hill Branch which was electrified in 1918, to White Marsh Station, a distance of 6.2 miles. The country through which it passes is very rolling, resulting in numerous cuts and fills, with a maximum grade of 1.5 per cent over a distance of 2.6 miles; curves of 2°, 4°, 7° and 9° obtain, the latter being 1,200 ft. long. It was necessary only to install an overhead catenary system without any additional sub-station, the existing sub-station at Allen Lane being adequate to handle the additional load.

It was found that, by electrifying the branch in this manner, the existing service could be handled at less expense than by steam or by any self-propelled car method, considering all fixed charges and operating expenses. The expense of contracting the overhead line was off-set by the fact that it was not necessary to provide any additional electric car equipment, the existing equipment being sufficient by proper adjustment of the train schedule. The present schedule provides six trains in each direction daily, two of which run to and from Broad Street Station, Philadelphia, and the remainder terminate at Allen Lane, at which point connection is made with electric trains of the Chestnut Hill Branch to and from Broad Street Station. The make-up of the trains is from two to five cars.

All the work of electrification except pole setting was done by the regular force of linemen used in maintaining the overhead wire structures on the Paoli and Chestnut Hill electrifications.

The line construction consists of Western cedar poles normally spaced 125 ft., with angle brackets supporting the standard catenary wire system made up of ½-in. galvanized steel messenger wire, 2/0 copper auxiliary wire, 3/0 phono-electric trolley or contact wire, 3/16 in. x 1 in. galvanized iron hangers, and 4/0 copper return wire attached to each bracket at the pole. The poles are



Terminal at White Marsh on Fort Washington Branch of Pennsylvania Railroad

back-guyed with ⅜-in. galvanized steel wire and approximately every half mile the end of the bracket is guyed to adjacent poles on each side. At one location for a distance of about 1,300 feet, a high fill with steep slope on each side necessitated span construction; here a pole was set on each side tied together at the top by double angle irons which support the insulator; these bents were spaced 250 feet.

Around the 9° curve, poles are spaced about 100 feet and special arrangement of catenary construction was necessary to prevent excessive vertical rise of wires due to pantograph pressure. This was accomplished in a unique manner by installing a second messenger wire supported from the same insulators to which the first messenger is attached, and a triangular hanger arrangement between the two messengers and trolley wire.

As with the Paoli and Chestnut Hill electrifications of the Pennsylvania Railroad, the trolley wire carries 11,000 volt, 25 cycle, single phase power for operating the multiple-unit electric cars. Each car is equipped with two Westinghouse No. 412-A single phase, series repulsion motors, each having an hourly rating of 225 horse power. Power is collected by a pantograph and conducted to a main transformer on each car and fed to the motors at a maximum of 430 volts across each motor; speed control is obtained by selected taps on the transformer.

Serviceability and Economics of 100% Locomotives*

C. A. Seley, Consulting Engineer

What is a 100 per cent locomotive? Sometimes it is a leading class of freight locomotive on a railroad, the tractive power of which is taken at 100 per cent and other locomotives are rated in the percentage their tractor power bears to the 100 per cent class. In an engineering way, it is understood to be a locomotive having a boiler equipped with heating surface sufficient to supply the amount of steam necessary for the cylinders of the locomotive, when operated at maximum capacity.

Locomotives are variously operated as regards their maximum capacity. Ordinarily, they are not so worked continuously, unless on long levels or on long sustained gradient and there should be some margin over the cylinder requirements to supply auxiliaries that call for steam and which are not ordinarily taken into account in the figuring boiler proportions. On modern locomotives, these auxiliaries may comprise air pumps, stoker engines, boosters, water pumps or injectors, blowers, train steam heat, electric lighting of headlights and sometimes train lighting, etc.

Considerations To Be Taken Into Account

A locomotive may go into service equipped with a 100 per cent boiler calculated on above requirements, but how long does it remain 100 per cent? The designer's rules are based on the use of good fuel, say coal at 14,000 B. T. U. and an evaporation of 55 lbs. of water per sq. ft. of firebox heating surface per hour, and a much smaller rate from the tube and flue heating surfaces, the ratio being dependent on size, spacing and length.

First, as regards the fuel; the bulk of coal supplied to locomotives will run from 12,500 to 11,000 B. T. U., a direct discount in heat value of from 10 to 20 per cent, which is reflected in boiler performance. The designer also assumes a coal burning rate of 120 lbs. per sq. ft. of grate per hour as the maximum rate for enonomical combustion. Grate area then is an essential feature and if accompanied with use of inferior coal, often produces an excessive coal burning rate. In fact, a 100 per cent boiler does not mean much unless the coal burning rate is taken into consideration.

A number of other things enter into the fuel question; draft, air admission, fire depth, arch location, and spark loss; all more or less adjustable features, contributing to or hindering proper combustion and affecting the 100 per cent performance.

Not the least of the foregoing items is that of air admission below the grates. There is some use of a ratio of 14 per cent of the grate area, but this is open to question considering the great variations of grates and coal rates. It is believed to be safer practice to base the total air openings below the grates on the total net cross sectional area of the flues and tubes which convey the gases to the front end. In order that there may be no vacuum in the ash pan, the above ratio should be 100 per cent and should be checked during the actual performance with a draft gauge.

The evaporation rates above cited are dependent on relatively clean surfaces for the heat transfer. Boilers must be kept clean and free from scale and accumulated deposit of sediment on interiors of heating surfaces; tubes and flues also kept open for free movement of gases.

Nothing pays better with respect to boiler operation than proper washing out and should be regulated with respect to size of boiler and amount of evaporation rather than a blanket rule governing all boilers, large and small, being washed at certain intervals. With proper boiler water circulation, the precipitated solids are carried to washout points rather than settling all over the heating surfaces, and the amount of evaporation and precipitation should rule rather than a uniform fixed time for all classes.

Any or all of these considerations are met with daily in locomotive operation and local conditions determine to what extent the boiler performance must be discounted. In almost every other line of machinery, a margin of capacity is deemed desirable; so that with operating conditions unfavorable, the margin can be drawn upon to keep up the desirable 100 per cent results. A so-called "Safety factor" of from five to twenty-five per cent is common practice in estimating, to keep on the safe side in many affairs of life.

There are very many well designed locomotives that lack just a little in respect to boiler performance, due to prevalence of some unfavorable feature of operation, although they may be figured on the 100 per cent basis, and be able to deliver it were all conditions favorable. In such cases, the endeavor to deliver full capacity is accomplished by increased costs out of proportion to the normal. A locomotive is only as good as its boiler and when liberal proportions are provided, the response in the case of extra demands or to meet unfavorable conditions are at hand and respond at normal rates.

Increase of locomotive boiler horsepower calls for an increase of evaporation requiring additional heating surface and stimulated water circulation. Assume a fairly modern locomotive already equipped with brick arch and superheated. Unless the tubes are excessively long, there is no advantage to be gained by their consideration, which leaves the firebox as the only location. A variety of expedients in the way of water tables or legs, water circulation means, etc., have been proposed.

The application, theory, and results obtained by the use of thermic Syphons are already well known. Briefly, they are vertical members located in the firebox so as to connect openings in the crown sheet, whereby water drawn from the belly of the boiler by gravity is afforded liberal passages for vertical movement and evaporation by heat transfer from the gases in the upper combustion region of the firebox.

Several important functions are performed by Syphons. They serve as stable and adequate support of brick arches and may be used in combination with arch tubes, if the brick patterns as required by the cross section of the firebox may necessitate such combined support in order to give proper access to side sheets for inspection and repair.

The vertical and horizontal extent of Syphon bodies above the arch supporting bulb form of the bottom affords additional heating surface of highest value, being in the hottest zone of combustion and having a one-way circulation.

The capacity and efficiency of high class stationary boilers is largely attained by the use of considerable height, affording the opportunity for the natural tendency of water circulation, which is upward when heated. The locomotive boiler is not of a favorable design to that end and the circulation is sluggish and restricted; resulting in temperature stresses in the structure and concentration of corrosive and pitting agencies, which shorten flue and sheet life and contribute heavily to maintenance expense.

It is entirely reasonable and has been thoroughly dem-

*A paper read before the Western Railway Club.

onstrated that temperature stresses and strains in the boiler structure, also concentration in boiler water has been largely done away with by active water circulation in any type of boiler. The Thermic Syphon is a means of attaining such circulation in locomotive boilers. The entire volume of boiler water passes through the Syphons several times an hour, due to their enormous pumping capacity, purely by thermic action, with no valves, stuffing boxes, or adjustable parts. The water circulation is, therefore, greatly enhanced by lateral displacement, taking the place of vertical movement, as found in other boiler types and corresponding in efficiency and stimulation of evaporation of the heating surfaces.

The circulatory function of Thermic Syphons has a double advantage of increasing the general evaporation rate, not only of its own but of all other heating surfaces; and of equalizing the temperature range in all parts covered by water, reducing stresses and strains and consequent maintenance expense and extending serviceability.

The volume of water circulation passing through the Syphons continues to flow even after the level of the water in the boiler may fall considerably below that of the crown sheet, flooding it and controlling overheating for a considerable range of drop. Another advantage lies in the fact of the design of Thermic Syphons affording a double plate girder brace or support to the crown sheet, preventing collapse and explosion in the event of extreme low water. This has been fully demonstrated in several cases on more than one railroad.

By inducing circulation coincident with firing up, it is much safer to utilize shorter time in getting up steam to put engines into service, and the temperatures are also more equalized in the cooling down process, both favorable to maintenance conditions.

The foregoing functions performed by Thermic Syphons, summarized, are as follows:

Brick arch support, very stable and dependable.

Heating surface of greatest value.

Thermic pump of high capacity for water circulation to stimulate evaporation surfaces and to equalize structure temperatures.

Insurance against crown sheet collapse.

A time saver in firing up.

An increaser of locomotive serviceability.

As a result of the foregoing features, Thermic Syphons are fuel savers and money savers on account of the fuel and maintenance reduction and additional serviceability.

Serviceability of locomotives is a topic really deserving a separate paper, as there are so many factors affecting it. No matter how many engines a road may have, unless the percentge of constant, every day and every minute serviceability is relatively high, the net return in service is not what it might be.

The contribution of Thermic Syphons to serviceability may be summarized somewhat as follows: The boiler capacity can be increased 10 to 15 per cent based on increase of equivalent evaporation, due to heating surface and circulation advantage already covered. Whether or not the available increase may be usable as developed HP., it is there in fuel economy of like proportions, account of increase of equivalent evaporation in the boiler operation.

The circulation promoted by Thermic Syphons will save time in firing up with safety and while in operation greatly reduce the range of temperature stresses of the structure; which, in plain terms, means a reduction of the stresses and strains that cause cracking and leaking. Obviating these means less repairs and maintenance costs, more time on the road, and less time in the shop, or awaiting shop, more service for the boiler material employed and for the locomotive as a whole.

It might be profitable, therefore, to consider the effect of Syphon application to a locomotive boiler already 100 per cent of the maximum cylinder horsepower. For that purpose a handy example of an accepted standard design will use the boiler of the U. S. R. A. Heavy 2-10-2 type, which has a liberal grate area of 88.2 sq. ft., which with a 120 lb. coal rate and 14,000 B. T. U. fuel should develop 3,254 HP. and require 1,231 equated sq. ft. of heating surface.

Inasmuch as the maximum cylinder HP. is 3,082, the coal burning rate would be 113.4 lb. coal per sq. ft. of grate per hour. These and other figures yet to be explained are shown in Fig. 1 following and are derived from the Cole ratios of boiler design.

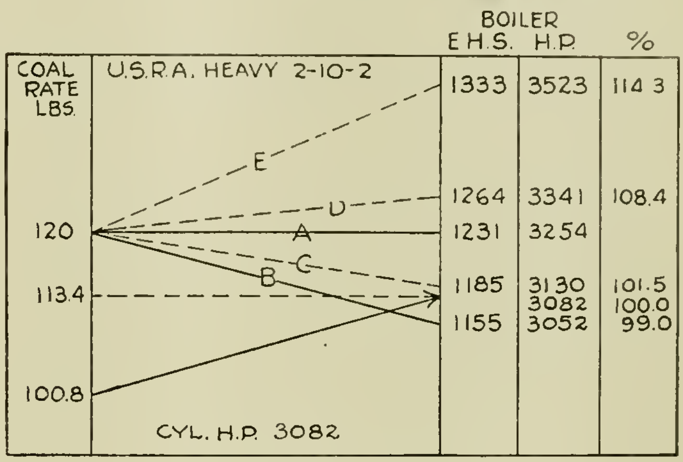


Fig. 1

Line A is the comparison line, that of the hypothetical boiler with 88.2 sq. ft. of grate as stated in the foregoing paragraph. Line B shows the combined heating surfaces of the firebox and combustion chamber; together with the flue heating surface equated to the 55 lb. rate of evaporation; amounting to a total of 1,155 equated sq. ft.; equal to 3,052 boiler HP. or 99 per cent of the cylinder HP. 30 sq. ft. of arch tube heating surface increases the foregoing figures to 1,185 E. H. S. and 3,130 boiler HP. shown by line C, or 101.5 per cent, a little more liberal than what we started out with, but so much better for the purpose, if it works out.

A design of Syphons for this type of boiler possibly combined with arch tubes to carry standard arch brick, should have about 109 sq. ft. of heating surface. Adding 109 sq. ft. to the figures of line B gives those as shown by line D, an increase to 108.4 per cent and of actual heating surface, all on the standard 55 lb. evaporation rate.

Numerous tests on various railroads credit Syphon-equipped locomotives as fuel savers over non-Syphon engines of the same class, in amounts running from 10 to 25 per cent and over on similar gross-ton-miles hauled. It is an impossible matter to obtain identical conditions in road tests, but by careful measurement of fuel and water, the evaporation of water per lb. of fuel can be obtained, which is purely a boiler figure and not complicated by the other road test conditions and variations. Numerous tests show an increase in the equivalent evaporation for Syphon-equipped locomotives of from 10 to 12.5 per cent. One test of a U. S. R. A. light Mikado type, tested before and after Syphon installation on the same engine showed an increase equivalent evaporation of 12.43 per cent for the Syphon arrangement.

If, instead of saving the coal, as afforded by the increase of equivalent evaporation, it is burned; the increase or total equivalent boiler HP. resulting is shown by line

E of Fig. 1, with figures indicating 114.3 per cent of the maximum cylinder HP.

It is obvious this amount cannot be used, but it does indicate the margin over cylinder requirements available for auxiliaries; for coal of less than 14,000 B. T. U. Value; for indifferent firing and boiler condition. It is not an excessive figure as compared with unusual practice in estimating requirements to cover safe practice, in meeting contingencies bound to occur and to play safe.

If the argument is safe, sane, and desirable for so-called 100 per cent locomotive boilers, it is all the more so for locomotives at all under boilered; as many, particularly of the older builds are.

The above figures of increased equivalent evaporation is not the total measure of fuel saved on Syphon-equipped locomotives for the reason that it represents a comparison of the net amount of fuel fired, which is utilized in evaporation and does not take into account the fuel, producing the wasted heat escaping at the stack, the unburned fuel in spark and ash pan losses.

The real fuel saving is the difference in the amounts fired to perform equal work and cover losses, and if a non-Syphon engine requires more net fuel for its evaporation, the gross amount of coal to cover the work and losses will be a greater amount proportionately than indicated by equivalent evaporation comparisons only; hence the larger coal savings as found in comparing ton-mile results; which, if it were possible to obtain strictly comparable figures, would give the true savings in fuel and water used.

There is also an operating gain; shown by the fact that Syphon-equipped engines usually make better time, for the simple reason that the addition of Syphon heating surface and circulation increases the boiler HP. capacity, and the better boiler wins. They may provide the capacity which enables better speed and avoids stalling. There is no doubt of considerable fuel saving due to the ability to take advantage of a good steaming engine and ample boiler capacity in making time and getting over the road. The relative economy may be gained, however, with less than fuel capacity.

Dynamometer car records in comparative tests do not always tell the whole story and like X-ray pictures need an intelligent interpretation. Many cars make record only at times of positive drawbar pull; no record on down hills and drifting, during which there may be negative work in controlling train speed, the means for this work coming from the fuel charged to the locomotive.

Study of a recent test disclosed that 27 per cent of the division mileage was down hill or drifting for stops; also that the non-Syphon engine stalled several times, thus piling up drawbar pull a million ft. lbs. The weather and temperature was not favorable. The Syphon engine in this competition did not stall, having greater boiler capacity and made better time without accumulating as many ft. lbs. of work, against which to measure the coal performance and apparently made a smaller saving of fuel per million feet lbs. of work and average drawbar HP., while the actual facts were that the Syphon-equipped locomotive pulled 3.18 per cent more tons in 7.29 per cent less time, using 22.52 per cent less coal and 12.03 per cent less water.

Even assuming as much as 50 per cent discount of the foregoing fuel and water savings makes a very respectable result when combined with the time saving of 7.29 per cent. This should appeal to the operating official and others working toward serviceability of equipment.

In the discussion of Mr. Kiesel's paper, read at the November meeting of the New York Railroad Club, on the 50 per cent Cut-off Locomotive, Mr. Lawford Fry made a very pertinent remark. He said, "In practice it is probable that the increased efficiency would not be used in cutting down the amount of coal and water consumed, but would be taken advantage of to give greater hauling capacity." He then quoted some 25 and 28 per cent increases of tonnage ratings to prove his point, showing thereby a greater return in haulage than possible by fuel and water savings.

There is no doubt of the interest of operating officers and the value to the railroads in increase of movement, shortening of time and of equipment serviceability rather than holding to present ton-mile-time performance and making savings in other accounts and directions.

The boiler as well as some other parts of the locomotive have gone on for years with little of attention or improvements of record. In the past few years more intensive study has been forced by the urge for greater locomotive capacity, on 4 ft. 8½ in. gauge rails that would seem about the limit of weight, although that word "limit" seems to have lost most of its significance.

Other speakers at the meeting, not in the railroad game, took up the differences in engineering practice and operation obtaining in the other branches, giving results by reason of continuity of service in thermal efficiencies, etc., and wondered at the near approach of the locomotive records with such inconsistent service. One of these gave as his belief that the end of locomotive improvement had not been reached. There is no doubt of this in the mind of every thoughtful engineer.

If the full significance of Mr. Fry's remark is appreciated, there can be no argument against utilizing the locomotive to the extent of its haulage capacity; for, if improved as to boiler economy by increased evaporative results per fuel unit, for normal service already proven, heavier or more continued service can be had at the same or better evaporative rates, thereby utilizing both capacity and the economies in fuel and water.

Inasmuch as the boiler capacity is the primary and limiting factor in this consideration, the locomotive should not be underboilered, on the basis of heating surface, circulation, fuel and maintenance.

These considerations and advantage possibilities are not limited to new power, but may be utilized in large measure and at relatively low cost to the present locomotives now in service.

In order to support the claims made for circulation effect on boiler maintenance, a few statements follow, gleaned from experience with Syphon engines on various railroads.

On one road where average flue life was 50,000 miles for certain territory and class of locomotives, a Syphon-equipped locomotive of that class ran 75,000 miles when the flues were removed. An inspection of the removed flues developed the fact that they might have remained in and given additional mileage of 25,000 to 40,000 miles, as the opinion of various officers of the railroad.

On another railroad, and in oil burning territory, where firebox temperatures are more varied and extreme than with coal, where the incandescent bed is a balancing factor, the lesser amount of flue work was very noticeable.

A railroad having a district with pronounced bad water and limited boiler performance established a mileage limit for locomotives; after which flues, flue sheets and side sheets should be renewed. A Syphon-equipped locomotive was placed in that territory, ran the mileage, and was shopped. The flues and firebox were found in such good condition that no renewals were made, the machinery repairs only were completed and the engine returned to service.

Many other cases as developed during the five or six past years of experience with Syphons might be cited, showing the favorable effect of stimulated circulation as a corrective to stresses and strains and elimination of pitting and corrosive action, the main causes of boiler maintenance expense.

The question then may properly be asked, what about the cost of Syphon maintenance? Again, based on six years of experience and service, the maintenance of Syphons is practically nil, as compared with that of any other locomotive boiler device which has been developed for capacity and economy. Its very simplicity of design and being welded in and made an integral part of the firebox, requiring only such maintenance and attention, inspection and care as other parts of the firebox, determine what that maintenance may be.

Taking the main features in turn, the upper connection or weld to or into the crown sheet, whether lap or butt weld, has given no trouble anywhere. There is but one seam in the Syphon body and neck. This being located out of the path of direct gas movement, gives no trouble. The staybolts do not break, as with both sheets equally exposed to heat, there are no lateral stresses of the staybolts as in the case of the firebox staybolts, and the main reason of such staybolt breakage. These bolts are so short that two standard depth telltale holes would almost meet; therefore, hollow staybolts of the solid, drilled type are used.

As all parts of a locomotive firebox are more or less in movement when fired up; expanding and contracting as a result of combustion temperature variations, Syphon bodies participate in such movements, and due to their design, most actively register at the throat sheet connection. The most suitable design of diaphragm plate or "breathing member" has been developed very carefully noting the life and repairs needed on a very considerable number of designs of diaphragm plates and connections at the throat sheet, the best of which are now incorporated as standard practice.

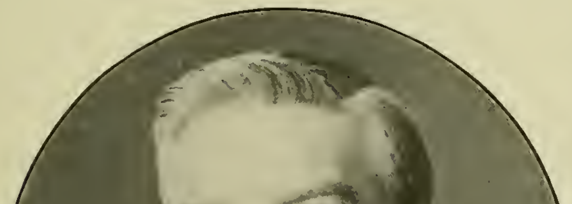
Many of those have run from shopping to shopping of the locomotive without any expense whatever. In case of cracking, it does not result in an engine failure and is readily repaired as a roundhouse job with a minimum of time and expense.

While it may be granted that with the earliest designs of throat connection, due to the fallibility of human endeavor in anything new, there were troubles to some extent; even then, they did not call for shopping and changing out until other firebox work was necessitated, it being entirely feasible to maintain the Syphons by roundhouse repairs until the regular shopping period enabled renewal of the throat sheet connection to the later and approved design.

The conservation of fuel is a question uppermost in the mind of the railway officer. Probably never in the history of railroading has there been witnessed such a determined effort to get every possible heat unit out of a pound of coal and utilize it as during the last year or two. The education of the man on the locomotive is important, but recognition of all that goes to constitute a hundred per cent locomotive is equally important. That within a few years over fifty railroads have adopted Thermic Syphons as standard on locomotives is an indication that railway officers very generally are keenly alive to the problem of fuel conservation and locomotive efficiency.

The Thirty-First Annual Convention of the Air Brake Association

The thirty-first annual convention of the Air Brake Association was held at Montreal, Que., Canada. The address of the president, George H. Wood, was broadcasted by radio from the ballroom of the Mount Royal Hotel, so that absent members had an opportunity to hear



George H. Wood, General Air Brake Instructor, A. T. & S. F. Ry., President Air Brake Association

the address of President Wood. This was the first time a president of a railway association in convention had addressed absent members by radio. Committee reports or papers were presented covering the following subjects:

Brake Pipe Leakage.

Condemning Limits of A. R. S. Standard Triple Valve Parts.

Passenger Train Handling; Graduated Release.

The Triple Valve Test Rack Operator.

Recommended Practice.

Individual papers were also presented as follows:

Freight Car Foundation Brake Designs, by W. G. Stenason, General Air Brake Inspector, Canadian Pacific Railway.

Reclamation of Hose and Fittings, by James C. Griggs, A. T. & S. F. Ry.

Reclamation of Air Brake Material, by A. Skinner, Air Brake Foreman, A. T. & S. Ry.

Methods of Interesting and Instructing Railway Employees in the Maintenance and Operation of the Air Brake Equipment, by J. P. Stewart.

We present herewith two of the individual papers, and will publish abstracts of the others together with the discussions in subsequent issues of *Railway & Locomotive Engineering*.

Reclamation of Hose and Fittings

By James C. Griggs, Hose Dept. Foreman, A. T. & S. F. Ry.

The reclamation of hose and fittings is a more important part of the air brake equipment of today than it was a few years ago, owing to the fact that material used in these fittings is not as good as it was at that time; and yet they cost as much and in many cases very much more.

Realizing the saving on reclaimed fittings, machines have been devised costing but a small sum, yet doing the work with the least possible labor and expense. The parts were all reclaimed from scrap received at Corwith yards.

The first operation in dismantling air and signal hose, is cutting the bolts. This is done by the use of a pair of shears. To operate these, an 8-inch cylinder is bolted perpendicularly to the floor. A lever arm connects the cylinder with the two blades, which works on the same principle as a pair of ordinary scissors; the shears being controlled by means of a foot lever connected to a straight air valve.

The second operation is removing the fittings from the hose, by the use of three cylinders, two of which are bolted to iron frames, four feet apart, the frames being especially made for this purpose. The pistons, with special jigs, move in opposite directions. The third cylinder which is a 10-inch non-pressure-head type, is bolted under the frame, and on a line with one of the 8-inch cylinders. Two lever arms connect with the 10-inch piston and pass through the frame-work, connecting with two jaws. These jaws are supported half-way between the two 8-inch cylinders.

The hose is gripped between the jaws, by operating a straight air valve on the line, and the two 8-inch cylinders, moving in opposite directions, remove the fittings. All serviceable fittings are sorted at the machine, while stripping. Nipples having dirt in the threads, are placed in a tank containing a solution of oakite and water. This solution is heated by a steam coil and dissolves the dirt.

A machine for stripping steam hose was made by bolting two 10-inch cylinders, four feet apart, on an iron base. Rods, two feet long, are screwed into the bolt holes on one end of the cylinders. On the end of these rods there is a 1-inch plate for the support of a jaw, which is bolted to the center of the plate.

The piston rods are made the same height as the plate, allowing five inches between the piston face and the stationary jaw. The pistons move upward by operating an air valve, gripping the mounted hose between the jaws. Two men, one on each side of the machine, remove the nuts from the bolts with wrenches. The rubber is cut from the fittings by a chisel.

Steam hose fittings are given hard usage, while in service, and the result is, that every coupling must be repaired. This is done by replacing worn out and broken parts with serviceable ones. Ten per cent of the steam couplings received, are the Vapor Car Heating Co. 302-Y. This type has no lugs for the interchange of the S 4-locker, so, in order to have them interchangeable, a lug of the same size as the one on the Vapor Car Heating 302-S is welded to the 302-Y.

All gaskets, used in these couplings, when worn down on the face, not to exceed 1-32 inch, are repaired by truing the face and gluing a composition ring, to the back, making them standard thickness. Owing to the various defects in the fittings, they are when mounted, tested at 100 lbs. steam pressure; those showing leaks are replaced.

Air and signal hose are given a test of 120 lbs. of air pressure, while submerged in a tank of water. Sixty per cent of the air hose couplings are repaired by inserting new pins. Eighty-seven per cent of the couplings, 88 per cent of the nipples, and 86 per cent of the clamps dismantled, are reclaimed.

A summary of the fittings reclaimed and the saving on each, for the year ended October 31, 1923, follows:

Class of Fittings	No. Pieces	Cost to Repair	Savings
Air	334,184	$13,441.35	$48,866.69
Signal	24,955	737.45	3,937.33
Whistle	641	12.82	122.84
Steam	76,473	11,376.60	25,218.43
Totals	436,253	$25,568.22	$78,145.29

Reclamation of Air Brake Material

By A. Skinner, Air Brake Foreman, A. T. & S. F. Ry.

The reclaiming of air brake material was started at the Santa Fe Scrap Yard at Corwith, Illinois in February 1913. Prior to that time reclamation, in its infancy, was more of an experiment than a reality, and the work was being taken care of at the various shops on the line. As time went on, the experiment proved to be a feasible one, until a most complete air brake reclamation and testing department has been developed.

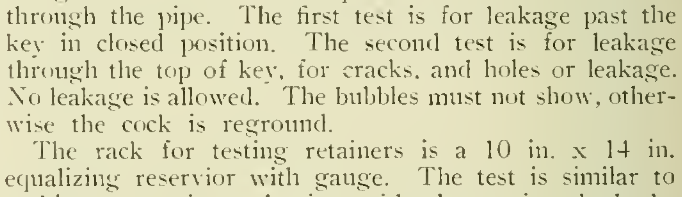
The equipment used has been made with material picked from the scrap pile, with the exception of the 3T Triple Valve Test Rack. The E. T. No. 6 Test Rack parts were all taken from scrap, at various times and assembled. The angle cock grinder was a nut tapper with four spindles, and by removing the housing used for tapping nuts, and applying another housing, (which was forged in the blacksmith shop from an original design) and applying simple chucks for holding the angle cock key while being ground, and adding a shaft in the rear of the grinder, placing four eccentrics that prevent the key from being ground in one place, we have as efficient an angle cock grinder as could be bought in the market. During the years it has been in service the cost of repairs has been so small that it is negligible. This grinder turns out fifty angle cocks in eight hours. The test for angle cocks is as rigid as can be made. A piece of 1¼ inch pipe is connected to the shop line, which carries 110 lbs. pressure. On this pipe a 1¼ inch cutout cock is set to give the effect of a branch pipe to the triple valve on a car. The angle or cutout cock is screwed into the cock being tested, and the full pressure is allowed to flow through the pipe. The first test is for leakage past the key in closed position. The second test is for leakage through the top of key, for cracks, and holes or leakage. No leakage is allowed. The bubbles must not show, otherwise the cock is reground.

The rack for testing retainers is a 10 in. x 14 in. equalizing reservior with gauge. The test is similar to making a service reduction with the engineer's brake valve. We allow fifty pounds of air to pass into the reservoir, then cut off the supply. The retainer handle is turned up to the retaining position, after pressure has blown down to the amount the retainer should hold. The valve is timed, and it must hold its pressure three minutes. With the standard spring retainer, we make two tests; one with the retainer in high pressure and one in low pressure.

The springs on the attached retainers are all gauged on a simple device, herewith illustrated, this being a piece of 3-16 inch boiler steel with slot cut on one side with two inch opening, this being the proper length of spring.

We find a large amount of these springs stretched as some repairmen stretch the spring rather than grind the valves in the retainer. Not a good method of repair.

Standard retainers, having all or part of the lug broken



Retaining Valve Spring Gauge

off, are drilled and a piece of 3-16 inch boiler steel, cut the same shape as the broken lug, is fastened to the back of the retainer with countersunk head stove bolts, at a very small cost, and retainers sent are out for further service.

At a very small cost, release valves are reseated, broken handles replaced and studs are renewed if threads are worn.

A large number of K triple valves are reclaimed. Most of these need minor repairs only, and are given a thorough test on the 3T test rack before going back into service. Exhaust ports that are broken are drilled and bushed. The bushing is the same length as the broken exhaust port, so that the retainer pipe will not be shortened. Triple valves with broken bodies are dismantled and serviceable parts are used in other bodies that are constantly coming into the scrap yard, so we do not buy repair parts with the exception of check case gaskets, cylinder cap gaskets, rubber seats and packing rings. We were at one time forced to buy pistons, as the groove wherein the ring fits, was badly damaged and no chance is taken with material possibly imperfect.

The feed valve test rack is of the Westinghouse design, but all parts used were culled from scrap. We do not as yet apply piston bushings, but we do apply regulating valve bushings, using a standard tool for this work.

Distributing valves are overhauled and some parts replaced, especially the exhaust valve and pin 18. Some repairmen try to remove the exhaust valve before removing pin 18, which results in a badly cut seat and distorted pin, but considering this type valve, we use very few new parts with the exception of gaskets.

The H-6 and S-6 brake valves are overhauled with perhaps a new gasket here and there, no new parts being used. The S-3 and A brake valves are treated in a like manner, new leather seats and perhaps a part of the handle being renewed.

We receive a number of angle cocks as well as cutout cocks with the thread worn off on the brake pipe end. These are drilled out to 1 23-32 inch, then run in a 1½ inch pipe tap and the cock rebushed. This bushing does not extend more than 1-4 inch so it will not interfere with the end sill on a car. This work was formerly done in a drill press, which was quite successful, but we have added a 14 inch geared head Warner-Swasey turret lathe to our equipment and by making an angle bracket that screws onto a spindle on the lathe and placing five tools in the turret, viz: centering tool, boring tool, reamer, Burritt pipe tap and counterboring tool, we can bore and tap one hundred angle cocks in eight hours without crowding the machine. By actual time, we have bored and tapped an angle cock in four minutes, but this crowds the machine. The average will be a run of one hundred cocks in eight hours.

Below is shown the amount of air brake equipment reclaimed from November 1st, 1922 to October 31st, 1923:

Article reclaimed	Pieces	Cost to repair	Saving
Self locking angle cocks	7,059	$6,784.32	$11,144.95
Old Handle angle cocks	1,528	1,775.49	637.61
½ inch cutout cocks	683	488.09	365.66
¾ inch cutout cocks	559	433.62	421.65
1 inch cutout cocks	1,100	797.19	908.44
1 ¼ inch cutout cocks	1,557	1,367.11	1,513.34
No. 2449 retainer	853	400.98	823.80
No. 43453 retainer	292	211.58	1,018.46
Release valves No. 2416	1,704	551.86	875.38
K-1 Triple valve	276	951.13	5,145.71
K-2 Triple valve	128	541.56	2,308.05
L3 Triple valve	15	59.68	927.47
F1 Triple value (plain)	6	37.27	50.51
F2 Triple valve (plain)	7	33.50	68.91
1 ¼ inch dust collectors	155	102.65	221.30
B6 Feed valve	5	20.45	42.10
C6 Feed valve	260	881.20	1,648.60
B3A Feed valve	122	488.75	51.29
G6 Engineer's Brake Valve	3	19.91	56.12
H6 Engineer's Brake Valve	3	14.56	75.05
S6 Independent brake valve	4	15.40	62.40
S3 Straight air brake valve	4	20.59	25.49
S3A Straight air brake valve	4	13.99	91.29
Oil cups No. 21414	296	211.22	414.46
1 in. No. 2048 steam portions	180	644.41	1,604.33
1¼ in. steam portions	99	489.64	1,527.91
Diaphr'm portions No. 20782	56	145.51	279.91
10 in. auxiliary reservoirs	2	9.36	9.65
8 in. auxiliary reservoirs	3	340.00	17.42
Total	17,498	$18,071.87	$33,096.61

B. & O. Fuel Conservation Moving Picture

The Chicago chapter of the International Railway Fuel Association held a special meeting Thursday evening, April 10, at the Hotel Sherman, Chicago, the feature of the evening being an unusual motion picture presented by W. L. Robinson, superintendent of fuel and locomotive performance of the Baltimore & Ohio. Among other things the chemistry of combustion is shown in this picture by means of animated characters, carbon being represented by a negro, oxygen by a police officer and hydrogen by a girl called the "Hydro-girl." this was the first showing of the film outside of the B. & O. lines and it was the concensus of opinion of those present that it will have an important effect in giving enginemen, firemen and other railroad employees a better idea of correct methods of firing and the importance of adhering to these methods if coal is to be used economically. The B. & O. is one of the first, if not the first railroad to use this method of carrying on educational work in its fuel saving campaign.

Great Northern Ry. to Run a Progress Exhibit Across the Continent

The Great Northern Ry. is to conduct a traveling historical exhibit on a tour from Chicago to the Pacific coast. The exhibit will contrast the equipment of 60 years ago with the latest type of all-steel passenger train cars and locomotive. The exhibit will be shown first in the Union Station, Chicago, May 14, after which the trains will proceed under their own steam over the Chicago, Burlington & Quincy R. R. to the Twin Cities, and thence on the Pacific northwest, stopping one day each in Fargo, Grand Forks, Spokane, Seattle and Portland.

The pioneer train of this exhibition, manned by a crew of veteran trainmen, will consist of the diminutive William Crooks, the first locomotive used on the Great Northern Ry. This toy-like engine will be "hitched up" to an antiquated combination coach and the original Pullman sleeper No. 9, which in its day furnished "luxurious" sleeping accommodation for the most prominent people of the nation.

Pullman sleeper No. 9 first went into service in 1859. For many years this unique relic of the days of Abraham Lincoln has been kept on exhibition at the Pullman works as a curiosity.

The spic and span all-steel train that will furnish the striking parallel, exhibited on a track alongside the ancient carrier, is to be one of the ten new Oriental Limited trains, the last word of the art, fresh from the Pullman shops where this equipment now is in course of construction for service between Chicago and the Pacific northwest cities, beginning June 1.

The two trains traveling together on exhibition, will arrive in Seattle in time so that the modern Oriental Limited train can run out of there June 1, as the first of the new Oriental Limited service going east, the same day the west bound Oriental Limited service is inaugurated out of Chicago. It requires eight of these Oriental Limited trains on the road all the time to keep this transcontinental service going.

The trains will be on exhibition two days in Chicago before they start their journey across the continent. They also will be shown in the Union Station in St. Paul two days, and two days in the Great Northern station in Minneapolis, Minn.

Owing to the safety appliances act, the Great Northern is unable to use the old link couplers on the pioneer train. Consequently, this old train will have all its antedated equipment, with this exception.

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The Real Value of Statistics or the Integrity of Accounts

The real value of statistics, statements or reports, resides in their accuracy or integrity, and unless they are properly arranged as to form, correct in compilation, and as a whole a true statement, then they are of little or no value.

In the past 25 years wonderful strides have been made in accounting methods, particularly so in the railway field where the use of similar or the same forms were used by all the different carriers in reporting to the Interstate Commerce Commission has since resulted in the use of standard forms and method, which is intended to produce absolute uniformity, and that each statement will be a correct display of the *true facts*.

In making a comparative study of operating statistics of class 1 railways for 1922, I. C. C. form 23178, many interesting features are developed, and on a careful analysis some of the items are misleading to an extent or degree that renders them of little value.

Detroit, Toledo and Ironton Railroad

In recent years we have heard much of the wonderful things accomplished by Mr. Henry Ford in the rehabilitation of the Detroit, Toledo and Ironton Railroad. Columns and pages have been and are being fed out to the public as to Mr. Ford's great achievement as a successful railway manager when as a matter of fact the most of it is pure bunk. The D. T. & I. is nothing more than a plant facility to Mr. Ford's great industries and as such it could not fail unless the industries failed, hence a statistical comparison of the present with former years prior to its acquisition by Mr. Ford, or with other carriers pure and simple, is a waste of time; it means nothing as the conditions are *not* comparable.

In comparing certain items of the D. T. & I. however, there appear features which suggest the advisability of changes in accounting methods that would tend to enhance the value of statistics.

Locomotive Statistics of Ten Railways

To more clearly illustrate the point, attention is invited to the following table of locomotive statistics of ten railways for 1922 including the D. T. & I.

Name of road	Miles per locomotive All service	Repairs per loco. owned and leased and cost per mile		Train load—rev. and non-rev., net tons	Average miles per day	
		Per engine	Per mile		Pass. engines	Freight engines
Penn. R. R.	23,603	$8,793	37c	865	58	114
N. Y. Central	23,969	5,526	23c	826	47	96
N. Y. C. & St. L.	36,877	9,349	25c	614	68	95
Hock. Valley	18,003	9,066	50c	1.431	36	96
Pere Marquette	24,122	6,873	28c	623	52	90
Mich. Central	24,539	5,502	22c	678	45	129
Ann Arbor	26,271	7,376	28c	759	60	116
T., St. L. & W.	35,467	6,607	18c	552	93	165
Wabash	26,365	8,779	33c	656	56	127
D. T. & I.	23,883	17,705	74c	839	62	100
Average	26,309	8,557	33.8c	784	57.7	112.8

It will be observed that the amount charged to locomotive repairs is $17.705 per engine, or 74 cents per mile while the average of the other 9 roads is only $7,541 per engine and 29.33 cents per mile and with the D. T. & I. included, the average per engine is only $8,557 per year and 33.8 cents per mile all of which prompts the following questions:

1. Does the caption or term, locomotive repairs in any stated period mean the amount of money actually expended in repairing wear and tear resulting from the service rendered *in that period* or;

2. Is it simply a statement of the amount expended in that year with no reference to the year or years in which the repairs accrued and to which they should have been charged.

Any one with an elementary knowledge of railways and operating results will not hesitate to say at a glance that it did not require $17,705 per engine, or 74 cents per mile to make good what service took out of the engines on the D. T. & I. in 1922 or anywhere near that amount. Therefore, the statement and others of which it is an integral part is to that extent in error.

If it be said, which is no doubt true, that the amount expended is correct, although much of this was deferred repairs from other years, then again it can be said that statements of those years are to that extent in error, and it is just such errors that effect or impair the integrity of statistical displays.

That the power on the D. T. & I. was in bad physical condition when Mr. Ford acquired the property is not only generally conceded but is borne out by the following:

In 1916 the amount expended on locomotive repairs was $2,419 per engine or 8.77 cents per mile, in 1921 $8,500 or 44.4 cents per mile, and in 1922 $17.705 per engine or 74 cents per mile from which it is clear that heavy repairs and possibly renewals and betterments were made and charged in 1922, that did not belong to that year at all, and had *no claim* on the operating income of that period.

Assuming the wear and tear resulting from service of locomotives on the D. T. & I. in 1922 was equal to the average of the other nine roads shown in the table, i.e. $7,541 per engine per year, then there must have been included in this account for that year the difference between $7,541 and $17,705 or $10,164 on 74 engines, making a total of $759,436 belonging to the expense of former years, the accounts of which had been closed, and were of course along with that of 1922 to that extent in error.

If an integral part of a machine or structure is weak, faulty, or defective, it effects the completed unit, and if any statistical items in accounts of railways are either in error, or if the different carriers' reports are subject to different interpretations, then the integrity and value of accounts are in jeopardy.

A Million Dollars a Mile

At the April meeting of the Society of Terminal Engineers, Mr. George W. Kittredge, Chief Engineer of the New York Central Railroad read a paper describing the Hudson River Connecting Railroad.

This new line or cut-off provides means of economical handling of all through freight, and such other traffic as should not be taken into the city of Albany, N. Y., thus choking an already congested "Bottle Neck," across the Hudson by bridge about twelve miles south of the city on easy grade lines and in this way, facilitate the movement of through traffic, relieve present and provide against future congestion at Albany, increase operating efficiency and capacity of the line and finally keep abreast of the times in modern transportation problems.

This wonderful engineering and transportation problem was first proposed in 1913 or eleven years ago, at which time the estimated cost was placed at about $12,000,000.00, the narrow minded people who can most always be depended on to oppose about everything a railway company may present, fought against it in the courts, legislature, etc., and only after about ten years of expensive litigation are they now about to offer the traveling public and shipper the advantages of this greatly improved facility, but instead of at a cost of about $12,000,000.00 it will cost approximately $25,000,000.00 and as the new line is 25 miles in length the cost is about: One Million Dollars a Mile.

The bridge will cost about $4,000,000 and the other portions about $21,000,000.00.

The New York Central is one of the progressive big railways in this country that is constantly building up its physical property and strengthening its financial position as well.

During the past eight years there has been added to property investment the following:

Taken from earnings	$142,000,000
Obtained from sale of securities..	198,000,000
Increase in property investment..	$340,000,000
Paid to share holders..........	$137,000,000

It will be seen that for every dollar paid share holders from earnings that more than one dollar, from earnings, has been actually ploughed back into the property, which shows that the questions of: (a) Maintenance. (b) Betterment. (c) Development and a strong financial position have been so combined and worked out, as to insure the present and future prosperity of this property as a modern, highly developed transportation unit.

Locomotive Force Feed Lubrication

Elsewhere in this issue is published an article on locomotive lubrication by W. J. Schlacks which reviews the development of this important detail of locomotive operation and maintenance and particularly mechanical or force feed lubrication.

Lubrication by mechanical means has long been successfully employed in the industrial and marine fields and quite generally on locomotives abroad. Force-feed lubricators or pumps have been used with good results in this country for a number of years and there are a number of different types of force-feed pumps in use, but on the majority of engines the hydrostatic cup is still employed.

In the article by Mr. Schlacks he points out the changes in locomotive design which prompted the introduction of force-feed lubrication for valves and cylinders and treats with special emphasis in explanation of the problem of lubricating superheated steam locomotives.

If the results which the author mentions as to increased life of cylinder packing rings on engines using force-feed lubrication can be even partially secured, then this particular development in locomotive accessories has made for a higher degree of efficiency and lower cost of locomotive operation.

Many of the points brought out in the article referred to were either unknown, or given little thought up until a few years ago, and we are confident that his contribution to this most important subject will prove both interesting and valuable to our readers.

1897 Bills Introduced in Legislatures in 1923

In the year just passed there were 1,897 bills affecting the railroads introduced in the legislature of 43 states, according to a special report issued by the committee on relations of railway operation to legislation of the American Railway Association. Only 377 of the bills were enacted and became law.

The contents of the bills introduced and passed provided for laws regulating almost every phase of railway operation.

One bill introduced in the Minnesota senate required the railroads to maintain a given number of men as a section crew to every six miles of track. It provided for a fine of not less than $25 nor more than $100 for the violation of each offense, each period of 24 hours constituting an offense. This bill failed to become law.

A bill introduced in the Missouri house of representatives required all freight shipments to move 60 miles per day. This bill passed the house but was defeated in the senate. The greatest average daily movement per car ever made by the railroads as a whole was 30.7 miles, in October, 1923.

In Nebraska a bill was introduced in the house providing that no railroad should maintain a curve of over two degrees, and for the rectification of all curves within a year on penalty of $500 for each delinquent day. This bill was postponed indefinitely.

In the Arizona house of representatives a bill was introduced prohibiting the use of telephones in the dispatching and handling of trains. The bill was defeated. The effect of its enactment would have been the establishing of many more telegraph stations, and would have, to a large extent, retarded the operation of all classes of trains, especially freight trains. A similar bill was introduced in California and Texas.

In the Iowa senate a bill was introduced limiting the speed of passenger trains. The bill failed to pass. If it had become a law it would have meant that on the main line of the Chicago, Rock Island & Pacific Ry., which passes through thirty towns, five additional hours would have been added to the time required for trains in crossing the state.

In the Colorado senate a bill was introduced providing that orders for cars for the shipment of live stock must be filed within five days of receipt; also that where 40 or more cars of live stock were offered for shipment no more than 40 cars should be hauled on any one train. The bill did not become law.

Locomotive Valve and Cylinder Lubrication

By W. J. Schlacks

In the beginning of locomotive operation the valves and cylinders were lubricated with chunks of tallow put into containers called "tallow pots" located in the top of the steam chest covers. When cylinder oil was first introduced, it was put into similar containers in the same location. It was difficult to control the amount of lubricant delivered, so that it was a case of either "a feast or a famine," in that at times entirely too much lubricant was fed into the steam until the supply was exhausted after which the valves and cylinders would run dry. It was a very uncertain affair; one never knew when starting out just how long his lubricant would last. Oil cups with pipes leading to each steam chest were later placed in the cab, thus ensuring more frequent filling and avoiding the necessity of the enginemen's risking injury in filling the tallow pots out in front while running.

The introduction of the hydrostatic lubricator filled a long felt want, because it could be located in the cab convenient for observation by the engineer. It could be regulated to feed a certain number drops per minute that ensured a certain consumption, more or less equally divided, for the entire trip. It held its position as a standard of locomotive equipment for over fifty years.

With the advent of the superheater locomotive, however, came demands for more exacting oil delivery. The increased length of the locomotives with the increased height of the point of oil delivery into the steam, on account of the larger drivers and cylinders with the piston valve above, together with the fact that the lubricator in the cab could not be raised to give the same incline to the oil pipes on account of the restricted overhead clearance, combined to put the hydrostatic lubricator at a disadvantage as a regular oil delivering instrument, by reducing the oil pipe pressure at the point of injecting the oil into the steam, thus making dependable regular delivery into the steam, against a full open throttle pressure, impossible.

The constantly increasing number of devices applied to locomotives for reducing the cost of operation, together with the constantly increasing number of signals and automobile road crossings that he must whistle, are consuming so much of the engineer's time, that it is being found increasingly difficult to demand his attention to frequently regulate, at so many drops per minute, the oil fed to the valves and cylinders, so as to deliver a sufficient amount, and not too much, at different speeds and cuts-off.

The more recent tendency towards longer locomotive runs to increase the mileage run per locomotive, thus reducing the out-of-service time and reducing the number of locomotives required for the service, has intensified the demand for an automatic oil delivering device of capacity to ensure sufficient lubrication the entire distance without depending on the whims of the different engineers as to how much oil is required to properly lubricate.

An automatic oil delivering device was also thought to be particularly desirable and economical on switching locomotives run by two or three crews in the twenty-four hours, in that it would deliver a definite quantity of oil only when the locomotive was working, so that one crew could not blame the other for using the entire twenty-four hours supply in eight hours.

The task set out to accomplish was to build an instrument that would deliver a predetermined amount of oil into the steam every revolution of the drivers, with nothing to turn on or off before or after filling, or before or after running, summer or winter in any climate; in other words one that was absolutely automatic in operation.

The Schlacks Force Feed Lubricator

The Schlacks force feed lubricator is attached to a bracket on the back head of either valve chamber.

A lever, that is actuated by the locomotive valve gear, works a ratchet that turns a cam shaft.

The cam is made so as to impart a quick suction stroke to the plungers which quickly fills the pump chambers with oil that is delivered to the engine in a series of successive short return strokes, completing the cycle.

Tests demonstrated that, notwithstanding the fact that the lubricator was delivering oil into the pipes at pracically every revolution of the drivers, the oil was not being delivered into the steam with the same regularity.

It was also found that the vacuum formed in the valves and cylinders while drifting and by the reduction in cylinder casting temperatures when standing still, would cause more oil to be drawn from the reservoir than the pumps delivered.

Considerable difficulty also was encountered due to condensation passing by the ordinary terminal check valve and gravitating to the bottom of the oil reservoir, where the pumps would take it up and deliver the water, instead of the oil, back into the stream; in fact, in some instances the rapid accumulation of the water in the oil reservoir would float almost all of the oil out; being displaced by the water.

It is an axiom that the oil pipe pressure at the delivery end in any form of lubrication must be in excess of the steam pressure into which the oil is to be injected.

On account of the fluctuating steam pipe pressures in a locomotive (sometimes running with full throttle and at other times drifting), it was early realized that a valve must be provided at the delivery end of each oil pipe that would maintain a constant oil pipe pressure in excess of the maximum working steam pressure, to avoid the engines running dry while the lubricator pump was building up an oil pipe pressure in excess of the steam pipe pressure.

These problems were solved by the design of a diaphragm terminal check valve, which:—

1. Maintains a constant oil pipe pressure.
2. Will not let condensation gravitate to the lubricator, and
3. Will not let a vacuum draw oil out of the pipe.

In other words, this valve permits a duplication of the lubricator pump's action at the delivery end of the oil pipe, irrespective of the length of the oil pipe or the steam pressure fluctuations into which the oil is being forced, and, in combination with the quick suction stroke plungers, ensures an injection of oil into the steam every revolution of the drivers.

Valve and Cylinder Lubrication of Superheater Locomotives

The hydrostatic lubricator oil pipe pressure at the point of delivery into the steam depends on the boiler steam pressure in the lubricator itself, plus the water-pressure-head between the lubricator and the point of delivery into the steam pipe. The difference in pressure into which the oil must be delivered and the hydrostatic-lubricator-oil-pipe-pressure at the point of delivery on modern power is reduced:

1. By reduced difference in height of the lubricator and the point of delivery into the steam, due to raising the point of delivery on account of the increased diameter of cylinders and the piston valve chamber on top, and the impossibility of increasing the height of the lubricator on account of the limited right of way overhead clearance.

2. By the increased oil pipe friction due to its increased length account of the greater distance from the lubricator in the cab to the steam pipe of the steam.

It has been proved that better cylinder lubrication can be obtained by injecting the oil a sufficient distance, twenty or more inches, above the valve to enable the oil to mix thoroughly with the steam before it reaches the valve, thus insuring a smaller proportion of oil passing out to exhaust by leaking valve packing rings. If, therefore, the point of delivery into the steam of the hydrostatic lubricator is made high up in the steam pipe, to get the benefit of thoroughly mixing the oil in all the steam, the difference in height from the point of delivery and the lubricator itself is so reduced as to make dependable, regular delivery impossible on long continuous runs with a fixed throttle. And, again, if the point of delivery into the steam is lowered to increase the oil pipe pressure by increasing the difference in height from it to the lubricator, the oil has not sufficient time to thoroughly mix with all the steam.

This has caused resort to different kinds of atomizing devices.

The reasons for adopting the force-feed lubricator, aside from the above facts, are:

1. It eliminates the human element.
2. It relieves the engineman of the duty of adjusting the feeds, which permits him that much more time for looking ahead.
3. It permits of official control of oil consumption.
4. It removes one more item from the already crowded cab.
5. It contains no explosive pressure.
6. It can be more readily filled.
7. It lends itself well to extended locomotive runs, which have been recently carried to limits, especially with the oil burning locomotive, heretofore thought impossible.
8. There is nothing to turn on or off before or after filling, before or after running, summer or winter, in any climate.
9. With ordinary careful handling, cleaning or draining oftener than when the engine is shopped is unnecessary.
10. The practically unlimited pressure into which the force feed lubricator can inject the oil.
11. The reduction of carbon incrustation due to delivering the lubricant only when the locomotive is running.
12. The increase in miles run to a pint of oil and to a set of valve and cylinder packing as well as valve stem and piston rod packing.

There are so many things besides the lubricator itself to be taken in consideration, to obtain the best results of valve and cylinder lubrication of superheater locomotives, that I believe it unwise to make a test of lubricator without, at the same time, arriving at a conclusion, from exhaustive tests, regarding all the contributing factors.

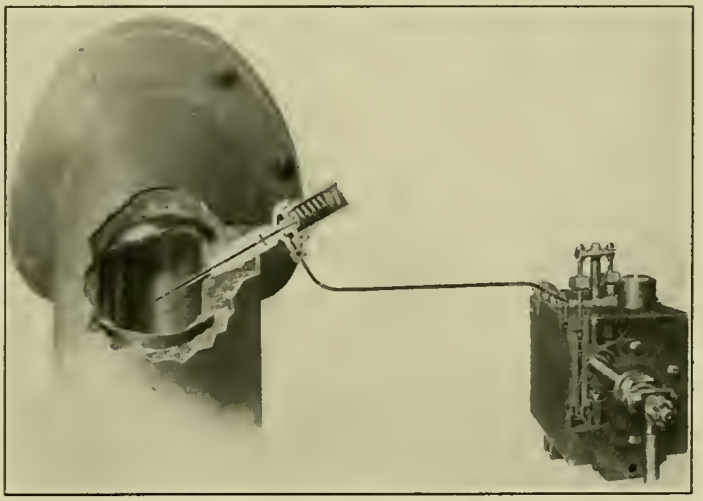
The lubricator is merely a lubricant delivering instrument, and the best is the one that will most consistently deliver a predetermined quantity of the best lubricant for the purpose into the steam, every revolution of the drivers, through the greatest variation of speeds and atmospheric temperatures, for the longest time, with the least attention.

Consistent with the above then, the best lubricant should be determined upon and used. Thorough investigation should determine the best place to inject the best lubricant by the best lubricator.

The above should be used together with the best form and material of valve and cylinder packing and bushings made to accurate dimensions and alignment. It is impossible to lubricate a locomotive whose valve and cylinder packing will not pack.

The best form of drifting device should be determined upon; one that is absolutely automatic that will not propel the locomotive and contains the least number of working parts requiring attention. Such a device would make relief or shifting valves unnecessary and even undesirable and would permit of the use of vacuum closing cylinder cocks. Such a device should avoid drawing front end cinders and gases into the valves and cylinders when drifting, which combined with excessive oil delivery, when not required, is the cause of carbon incrustation.

Difficulty in lubricating certain locomotives has been experienced until it was discovered that the gauge cocks and water glasses were located too high above the crown sheet thus causing working water on account of a too restricted steam space.



Illustrating Movement of Oil From Reservoir Into Steam Pipe of Locomotive, Schlacks System Force Feed Lubrication

The greatest number of two feeds force feed lubricators in use are bolted to a one inch thick wrought iron bracket which is attached to the back head of either left or right valve chamber by three long valve head studs.

The lubricator lever is connected to a driving rod which is actuated by a stud connection on an extension of the locomotive valve gear combination lever.

The oil is conveyed through one-quarter inch by three-eighths inch annealed copper tubes from the lubricator to diaphragm terminal check valves located as high as possible in both the left and right outside steam pipes. The check valves are set to maintain oil pipe pressure of three hundred pounds per square inch.

The check valves are screwed into steam pipe plugs, which at an angle of 30 degrees from the horizontal, convey the oil to the center line of the steam pipe.

A one-quarter by three-eighths annealed copper tube run against the boiler under the lagging from an independent connection to the fountain near the cab, conveys steam to a heater chamber under the lubricator for heating the oil in the reservoir. This heater line is never regulated.

A three-eighths inch black iron pipe drains the heater chamber into the cylinder exhaust channel, or into the air pump exhaust.

Draining into the cylinder exhaust channel, obtains an increase of temperature from an increase of heating steam pressure when the radiation is increased by running. The increase of heating steam pressure being due to the cylinder exhaust channel resistance when running.

The length of the lubricator lever and the travel of the pin on the combination lever determine the amount of oil delivered per revolution of the locomotive drivers and the length of the lever is such as to ensure sufficient oil being delivered at the normal running cut-off.

The following is an instance demonstrating the advantage of eliminating the human element:

An engineman was asked by an observer how many drops per minute he set the hydrostatic lubricator to deliver. The observer counted 18 drops per minute, while the engineman replied "Four drops to each side."

Sometime later the observer noticed the lubricator had quit feeding entirely, so he asked the engineman: "How many drops is it feeding now?" When the engineman discovered the lubricator was empty he accused the terminal forces of not having filled it. This divided responsibility is difficult to combat.

Superheater locomotives equipped with force-feed lubricators run from shopping to shopping with one set of cylinder packing, and a number of Mikado locomotives were overhauled whose cylinder heads, at the special request of the master mechanic, were not removed because the packing had not been changed since the locomotives were received new, and they wanted to know how much additional mileage could be run with the same set.

Broken Rails

Two reports on broken rails that caused derailments and loss of life have been recently published by the Bureau of Safety. In one the derailed train was a freight train whose wreckage was struck by a passenger train. The broken rail was badly shattered, some of the damage being due to a portion of the train running over it after it had broken and before derailment occurred. Twelve feet in length of the rail an intermediate section, was broken into short fragments. There were pieces of the head, separated into halves, and detached fragments of the web and base. Not all of the smaller fragments were recovered. At the receiving end there was a partially split section, 4½ feet long; at the leaving end an intact section 16½ feet long.

The recovered fragments, from the intermediate part of the length of the rail, showed the presence of a longitudinal seam at the center of the head. This seam constituted the cause of its failure. Some of the fragments showed the plane of rupture had traveled easterly, on others it had traveled in the opposite direction. The incipient point of rupture, longitudinally, was not shown by the recovered fragments, but was located, of course, at the place whence the plane of rupture changed directions. Split head fractures have definite origins from which they extend longitudinally. Vertically they develop upward and downward from the seams at which they originate.

The longer fragment of the leaving end showed no trace of the split head fracture. The head of the shorter fragment was partially split. The plane of rupture had deflected and was approaching the gauge side of the head in this fragment. It terminated in the section covered by the splice bars, at a distance of three-eighths inch from the side of the head, here nearly separating it vertically.

After the plane of rupture had deflected from its course at the middle of the head it passed through metal microscopically sound. Whether the rail first failed abreast the incipient point of the split head fracture or elsewhere along its length the recovered fragments were insufficient to indicate. It does not follow necessarily that final rupture of the rail occurs at the origin of the split head itself.

Describing the photographs and micrographs reproduced herewith illustrating this rail and one other, each of which displayed a fracture of this kind, Figure 1 shows a cross section of the halves of the head of the rail involved in the present accident as they appeared after polishing and etching with tincture of iodine. The web and base of the rail are shown in outline.

The place of rupture, in vertical direction, had its origin at a longitudinal seam at the center of the head. A star is placed on the cut at the side of the seam, for identification.

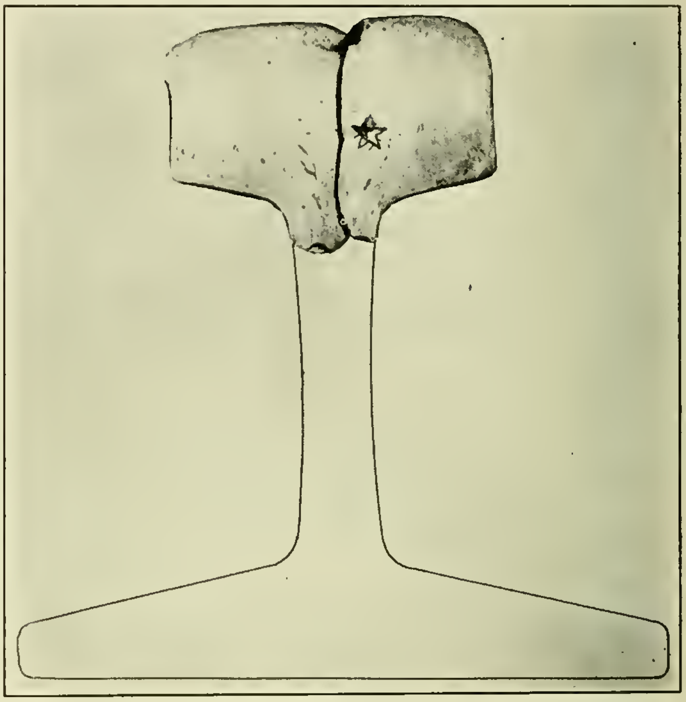


Fig. 1.—Cross section of head of rail with outlines of web and base, surface polished and etched with tincture of iodine. Fracture began at seam at the center of the head, abreast star placed on the cut for identification.

Figure 2 shows a cross section of the rail near the receiving end, as it appeared after polishing and etching with tincture of iodine. At this place the plane of rupture has approached within three-eighths inch of the gauge side of the head.

Pronounced markings appeared on this iodine etched cross section; darkened areas, dots, and dashes. Each mark has some significance but for the most part they would hardly exert an appreciable influence in promoting rupture of a rail, the gravity of their presence depending upon their position and size.

The dark zones bordering upon the edges of the split head plane of the rupture are without significance in respect to the development of the fracture. The illustration shows how an erroneous aspect may be given a portion of the etched surface through the presence of some foreign substance. The metal in the opposite halves of the head was substantially alike in structural appearance. In general, rails are remarkable for their symmetry of appearance on opposite sides of a vertical center line.

The markings on the cross section of the rail shown by Figure 2 were microscopically examined in three places. Near the center of the head a darkened spot was displayed, occupying a place near the element on which the seam causing the split head was located. This spot, toward which an arrow points on the cut, was photographed oversize and enlarged to 8 diameters appearing as shown by Figure 3. These inclusions would be expected to impair the strength of the metal in its resistance of lateral

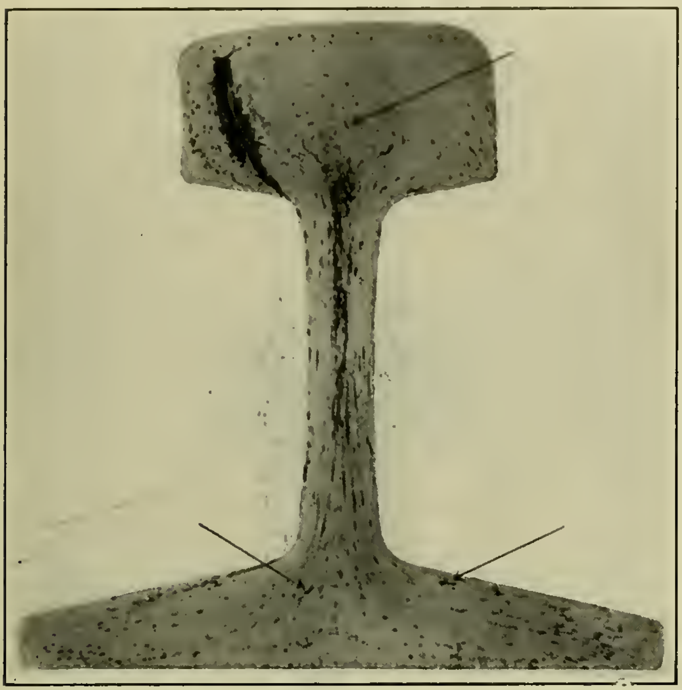


Fig. 2.—Cross section of rail near receiving end. Split head fracture had approached within three-eighths inch of gauge side of the head. Surface polished and etched with tincture of iodine. Dark borders of fracture not significant.

strains, and lead to the formation of a split head fracture.

The examination was next directed to some dark lines near the upper surface of one of the flanges, marked for identification with an arrow, on Figure 2. An inter-

Fig. 3.—Photomicrograph of darkened spot near center of head of rail. Transverse section, 100 diameters magnification

rupted line of minute slag inclusions was the characteristic feature of this streak in the metal.

It is believed that the slag streak in the head was responsible for the accident, and the examination of these spots furnish an illustration believed to represent a structural condition adequate to cause the development of a split head, provided it was located in the critical zone in the head. In the base it was not situated in a danger zone and its presence there can be ignored.

The last remark brings to notice the feature that structural conditions to be menacing must occupy certain definite danger zones in the cross section of the rail, and that vulnerability is found in certain localities with which the intensity of wheel pressures bear a definite relation.

It is believed that seams, such as these, if present in the head, critically located and oriented, would lead to the development of split head fracture. Split head fractures indicate that the effects of wheel pressures penetrate to the centers of the heads of rails. Evidence of such penetration is also furnished from other sources. It is not believed a chance occurrence that a seam in the center of the head is situated in a plane of rupture originating elsewhere: the seam is held to be the cause, rupture originating at its locus.

Without taking up the question of eliminating streaks, or entering upon a discussion whether they can be eliminated, it may be remarked that it is important to ascribe the formation of split head fractures, as well as all other types of fractures, to their proper causes. Erroneous explanations of those inadvertently ascribed to irrelevant conditions stand in the way of reaching corrective measures if they are attainable.

Possibly the matter of segregation has been given a greater prominence with respect to certain types of fractures than is justifiable. A rail of unusual degree of segregation was examined in connection with the accident under consideration. Its carbon content in the head was 0.85; in the web 1.33. This rail, 130 pounds weight per yard, displayed a split head fracture. The cause of the fracture was a longitudinal seam located near the center of the head. The fractured surface presented an appearance common to split head fractures, and identical to that of the 100-pound rail involved in the present accident.

Objections to segregated metal would be valid if segregation was proven to present an unfavorable relation to the type of fracture under consideration. This 130-pound, rail segregation was apparently beneficial in its results rather than detrimental. Its presence probably saved the outer half of the head from being detached from the web; possibly averting a derailment.

Segregated metal occupies the same place in the cross section of the rail as a pipe. A pipe results from a cooling cavity in the ingot from which the rail is rolled. Seams result from slag inclusions. There is no necessary relation between these two phenomena. It has not come to notice that either piping or segregation has been a contributory cause in split head fractures. Each is a distinct type of rupture resulting from different antecendent conditions. Split head rails are of frequent occurrence. Failures from piping are seldom witnessed, notwithstanding which split head rails, in many quarters, continue to be called piped rails, a misleading misnomer.

There is a tendency to underestimate the gravity of split head rails, due to the circumstance that detection is possible at certain stages in their development. The ratio between width and depth of fracture is so unfavorable, however, that difficulty is presented in the early detection of split head rails. The minor and not the major dimension of rupture only afford the means of detection.

It is conceivable that cooling strains may play a part in the formation of split head fractures. They appear the dominating if not the sole cause of the formation of shattered zones in the heads and bases of rails. Cooling strains may concentrate upon planes of structural weakness, such as slag inclusions and originate incipient nuclei of subsequent fractures. Accelerated rate of cooling has such an influence, and possibly size of head of rail modifies thermal effects.

As to corrective measures, a certain degree of control is probably at the command of the steel maker, in respect to the amount of entrained slag. The aggregation and location of acicular groups do not appear controllable features. Flattened inclusions of extreme width occupy certain parts in the cross section of the rail, incident to the contour of its outline, notably in the web and upper side of the flanges. Roll design must be adapted to meet the demand for rails of given shapes, and such influence on the disposition of the inclusions is unavoidable. Flattened inclusions in the central part of the head, vertically oriented, are without doubt menacing. It is not apparent how to control the shape of inclusions in this part of the rail. The elimination of all inclusions would remove those from the danger zone as well as other parts of the cross section. Greater freedom from inclusions would mitigate the situation in respect to split head fractures.

It does not follow that escape from one type of fracture will not involve an accentuation of troubles in some other direction. One fact is conspicuous; rails are overstrained members. Such has been the case in some degree from the very start of carrying loads on wheels. A railroad track is not a permanent structure, in an engineering sense. Local ovestraining of the metal adjacent to the running surface has always been the case. It can best be endured when the volume of affected metal is of moderate extent.

In conclusion, the failure of the rail involved in the present accident was due to a split head fracture. The origin and cause of the fracture was a longitudinal seam located near the center of the head. The fracture developed vertically, splitting the head into halves and extended lengthwise the rail nearly half its length. In its course it followed the seam in the head for the greater part of its length, but deflected toward the gauge side as it approached the receiving end. In the latter part of its course the plane of rupture passed through metal macroscopically sound.

Split head rails, at times, admit of detection. A dark streak along the middle of the running surface is an accepted manifestation of a split head. Lateral expansion of the head is slight in amount compared with the vertical depth of the fracture and therefore affords a somewhat precarious warning of the extent of the fracture. Its inadequacy as a reliable index of the gravity of the case is probably the reason for the occurrence of accidents arising from this cause rather than disregard or neglect of the indications.

The second accident occurred on a curve of between 4° and 5° under a passenger train running at a speed of between 35 and 40 miles an hour. The rail was of 90-lb. section, was worn as shown by the illustration Fig. 4 and was located on the high side of the curve.

The fracture was one of tension having its origin at the lower corner of the head on the gauge side of the rail. This circumstance indicated that a centrifugal force, or outward nosing of the engine was the immediate cause of the fracture, and since the derailed wheels passed through the opening in the track without striking the facing end of the short fragment that the train was not running at a high rate of speed.

The fractured surfaces showed no defect in the steel, nor was it a fracture of a progressive type. Rupture began at the lower corner of the flange-worn side of the head where the metal had been embrittled by the action of the flanges of the wheels.

But physical and chemical tests made of the rail showed it to be sound and of good quality.

Flange wear was shown incident to its position as a high rail on a curve but not of unusual amount. All parts of the periphery of the head, exposed to contact with the treads and flanges of wheels are modified in structure, strength, and ductility. Different effects, however, are experienced at different parts of the running surface. At the outer part of the head the metal is crowded outward, laterally. Medium metal is flattened. Lateral flow occurs on the gauge side half of the head, arrested somewhat by the fillets of the wheels. The flanges of the wheels cause flow and shearing of the metal down the gauge side.

A profound disturbance of the metal in the top of the head of the rail results from the action of the wheels. It is important that this fact be recognized, since it constitutes the crux of the rail problem. The manner of failure of rails leads to this conclusion.

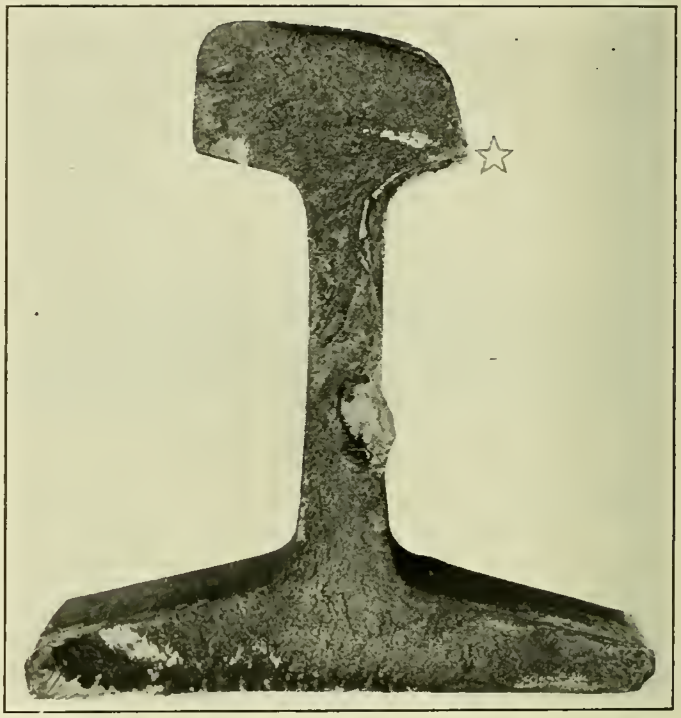


Fig. 4.—Fractured surface of leaving end of long fragment of rail. Origin of fracture at lower corner of the head gauge side at point indicated by a star.

Since the origin of rupture was on the gauge side of the head, it signifies that that part of the rail was exposed to a strain of tension at the time of rupture. The gauge side of the head is not ordinarily put into a high state of tension. Under vertical loads it is in compression. The presence of a horizontal force is needed to account for such a rupture as witnessed on this occasion. The nosing of engines causes strains of this kind and furnishes the most plausible explanation of the fracture, the section of the rail in front of the engine being the part put into a state of tension.

On tangent track irregularities in alignment have been responsible for fractures of this kind. The embrittled state of the surface metal and the relatively small section modulus of the rail in lateral direction, each facilitate rupture in a sidewise direction. Excess speed was not a factor in this case.

Considering the part of the rail embraced by the splice bars as a fixed end and the receiving end of the rail as the long arm of a lever, then the application of a sufficient outward thrust on the long arm would rupture the rail. It is believed that this rail was ruptured in substantially the manner just described.

Shop Kinks

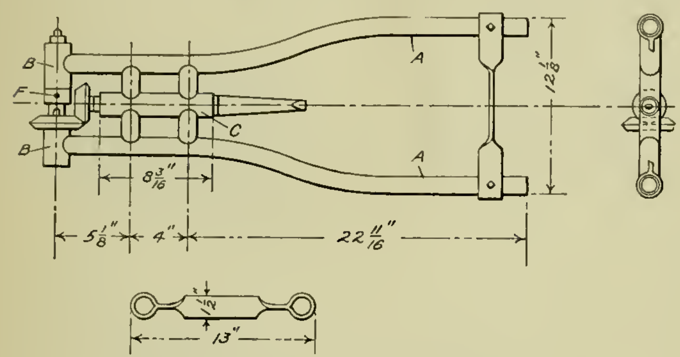
Some Handy Devices in Use on the Erie Railroad

Device for Angular Drilling

The hand ratchet drill can be set up and worked in very close quarters, but where power is to be used for driving the drill there must be room for the motor unless a flexible shaft is used.

In order to meet this requirement of securing room for the motor, where there is no space for it in line with the hole to be drilled, various designs of angular drills have been developed.

The one that is shown here was designed and is in use in the Meadville shops, and possesses the two-fold advantage of strength and lightness. Its general shape is shown by the engraving of the assembly. It is built up of steel tubing with all joints brazed. The frame sides *A* are of 1 5/16 steel tubing ⅛ in. thick. The tubing



Assembly of Device for Angular Drilling

at *B* and *C* which serves as carriers for the spindles has an outside diameter of 1⅝ in. and is ⅛ in. thick. The back ends of the side frames are stayed and held together by a flat steel clamp of 1½ in. by ⅜ in. metal that is given a quarter turn between the points of attachment, for stiffness, as this is held in place by a ¾ in. set screw in each frame.

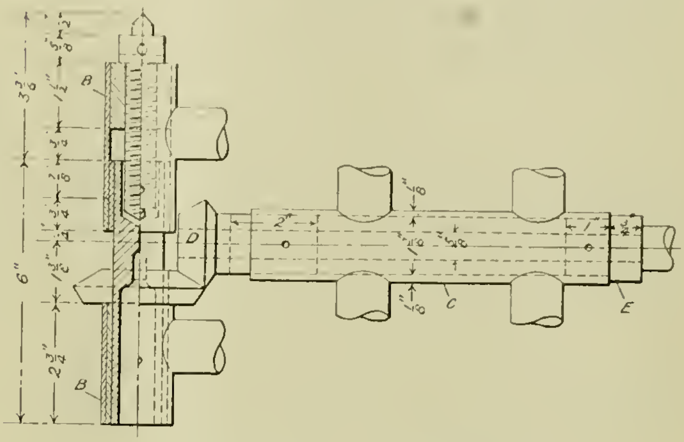
The central tubing *C* which carries the main driving shaft is bushed at each end with brass bushings which serve as bearings for that shaft. At the back end this bushing is 1 in. long and lies wholly within the tubing. At the front or working end it is 2 in. long and projects ½ in. beyond the end of the tubing. These bushings are bored for a ⅝ in. diameter driving shaft. This shaft has a keyway cut at one end to receive and drive the beveled pinion *D*, which serves as a collar for the shaft. At the other end it carries a collar ¾ in. thick and 1½ in. in diameter, and back of this it terminates in a No. 2 Morse taper shank that is 5 3/16 in. long that enters the socket of the motor. The beveled pinion *D* has a maximum pitch diameter of 2⅛ in. and is cut with 20 teeth. The gear on the drill spindle is 3 3/16 in. at the maximum pitch diameter and is cut with 30 teeth.

The overall length of the two drill spindle tubes *B* is 8¼ in. The nut for the feed screw is a steel bushing 1½ in. long that is pressed and brazed in the upper tube, and it is cut for the ¾ in feed screw with 10 threads to the inch. At the lower end of the upper tube there is a brass bushing 1⅝ in. long that is bored out to 1 1/16 in. in diameter to serve as a bearing for the drill spindle. This spindle has a pocket at its upper end to receive the end of the feed screw, and at the lower end it is bored out with a socket to receive a No. 2 Morse taper shank drill.

The lower tube, which is 2¾ in. long carries a brass bushing for its whole length; this bushing serving as the bearing for the spindle.

The thrust is taken by a collar *F* which is held by two set screws.

It will be seen that, as the feed screw is backed out



Details of Device for Angular Drilling

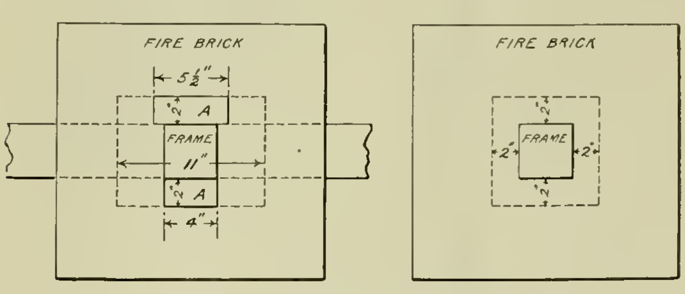
of its nut against an old man or other backing, that the whole frame is moved ahead with the drill, and that a hole about 2½ in. deep can be drilled.

Furnace and Oil Burner for Welding Frames

It is, perhaps, to go back to prehistoric times to speak of oil burning for welding purposes in these days of rapid autogenous work. But there may be places still that have no thermit or oxy-acetylene or electric welders, but where an air supply, a few fire brick and some wrought iron pipe are available; and, for such places the simple furnace and oil burner developed at Meadville may be, at least, suggestive.

The frame, after being properly prepared has a plain firebrick furnace built up about it. There is just space about it for the insertion of the burner, that is there is an opening of 2 in. on all sides as indicated. Then when the welding is being done the bricks *A* are to be removed.

The burner is made of short lengths of pipe varying



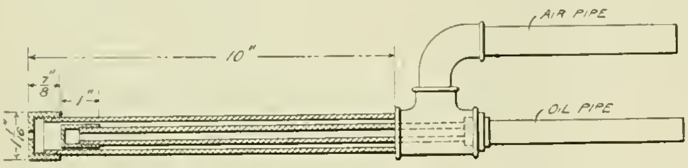
Furnace for Welding Engine Frames

from ¼ in. to ¾ in. in diameter, with a base made of an ordinary ¾ in. tee with a ½ in. side opening.

A ½ in. pipe coming into this side opening is the air pipe. At the right the opening in the tee is reduced to take the ⅜ in. oil pipe, and this, in turn is reduced, inside the tee to take a ¼ in. oil discharge pipe. The end of this oil pipe is covered with a cap in the sides of which six holes each 1/16 in. in diameter are drilled.

Outside of this small pipe a ¾ in. pipe is screwed into the left hand side of the tee and this is closed, at the end, by a cap in which a hole ⅛ in. in diameter is drilled.

Air under a pressure of 80 lbs. per sq. in. is used, and



Oil Burner for Heating Engine Frames

the oil is forced in under a pressure of 15 lbs. per sq. in.

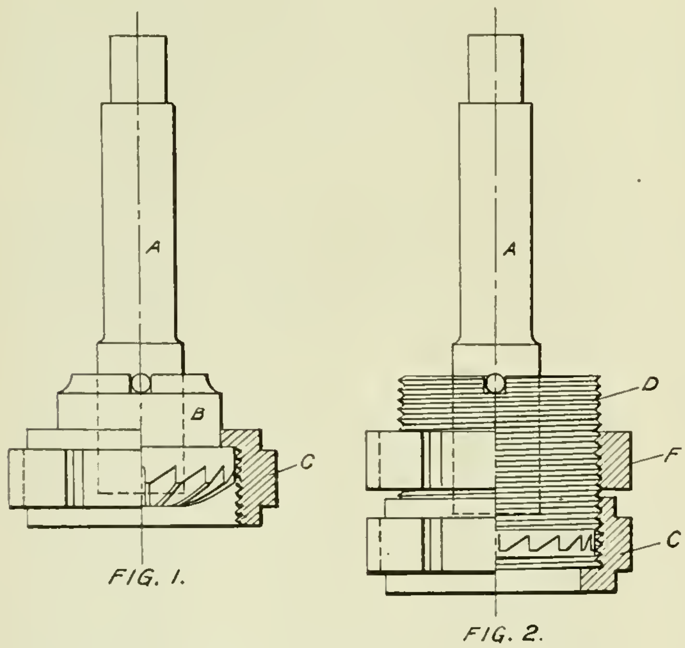
The oil is thus injected sideways into the stream of air near the outlet of the burner and is so caught up by it that it is completely atomized and the mixture of oil and air issuing from the ⅛ in. hole in the cap of the ¾ in. air pipe is a highly inflammable mixture and burns with an almost complete combustion.

Reamers for Injector Coupling

A handy hand reamer for reaming injector couplings is here shown. These are, of course, to be ground afterwards to a steam fit, but if they become worn or cut they may need just the little touching with a reamer that this tool will give them.

There are two reamers in the set, one convex for the pipe connection and one concave for the injector seat. An assembly of each is shown in Figs. 1 and 2 respectively.

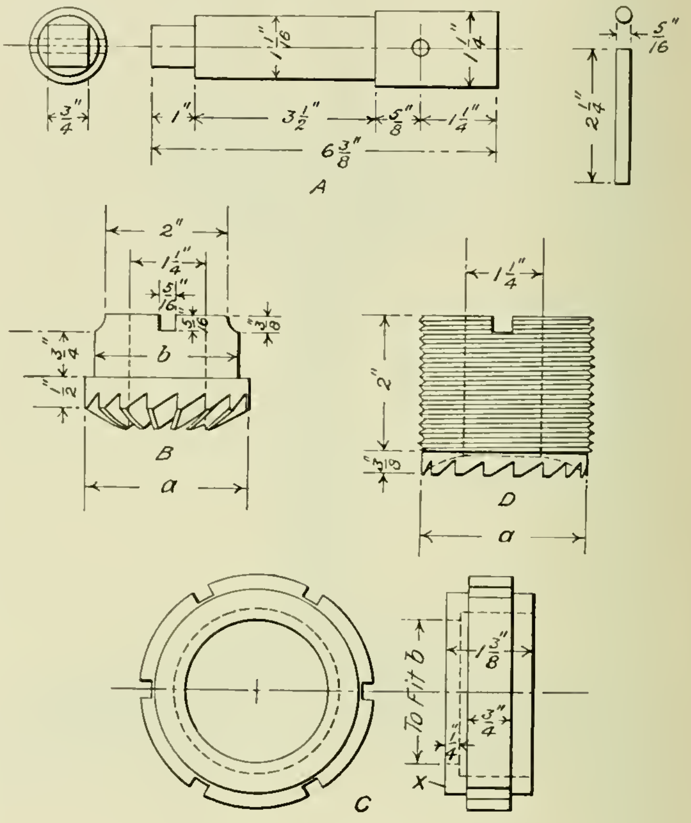
In Fig. 1 there is a stem *A* which is used for all sizes



Convex and Concave Reamers for Injector Couplings

of reamers. The reamer itself is shown at *B* and also in detail separately as are the other parts. The nut *C* is the same nut as that belonging to the coupling upon which the reamer is to be used. The method of operation is apparent. The nut is slipped over the reamer and screwed on to the coupling far enough to hold the reamer in place, and the latter is then turned by a wrench on the square end of the stem *A*.

With the concave reamer the nut *C* is slipped in place and the reamer *D* is screwed into it until its face has a bearing against the ball face of the coupling. It is then locked in that position by the lock nut *F* which is screwed over the thread cut on the outside of the reamer. This last is, of course, the same both in diameter and pitch as that on the injector and coupling. The check nut is made from one of the regular coupling nuts *C* by turning off ¼ in. of the face at *X*. This cuts away the overhanging lip of the nut and leaves it of the straight through type. And it is the number and diameter of the threads on the



Details of Injector Coupling Reamers

coupling nut that determines the size of reamer that is to be used.

There are four sizes of these reamers in use, the variable dimensions of which are indicated in the following table:

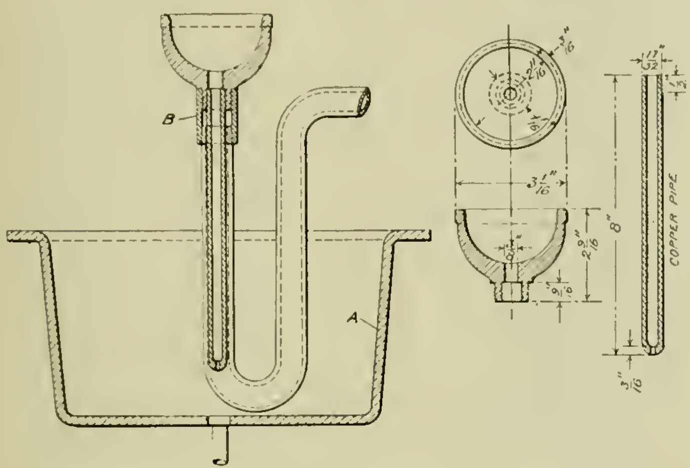
No.	a	b	No. Flutes	No. Threads
1	2⅝ in.	2⅜ in.	23	10 per in.
2	2¾ in.	2⅜ in.	25	14 per in.
3	2 11/16 in.	2⅜ in.	23	10 per in.
4	2⅞ in.	2⅜ in.	27	10 per in.

The greatest depth of flute is ¼ in. and the standard radius of curvature of the cutting edge of all reamers is 2⅜ in.

Sanitary Drinking Fountain

The sanitary drinking fountain is one of the innovations of recent years and those who are responsible for the establishment and maintenance of public drinking places are obliged, in some states to install either a sanitary fountain or furnish individual drinking cups. For shop purposes the fountain is the alternative almost universally adopted. The one illustrated was designed at the Susquehanna shops and is of exceedingly simple construction. There is the basin *A* connected at the bottom with the waste. This basin is $9\frac{1}{2}$ in. in diameter at the top and $5\frac{1}{4}$ in. deep. The water pipe is of ordinary ½ in. iron pipe bent into U-shape and threaded for the usual pipe connection *B*.

The drinking cup is 2 11/16 in. in diameter on the inside and 3 1/16 on the outside, with the other dimensions as shown in the detail. Its nipple at the bottom is threaded both on the inside and outside. The outside thread takes the ½ in. connection with the water pipe and into the inside thread there is screwed a ¼ in. copper pipe 8 in long and closed in at the bottom leaving a



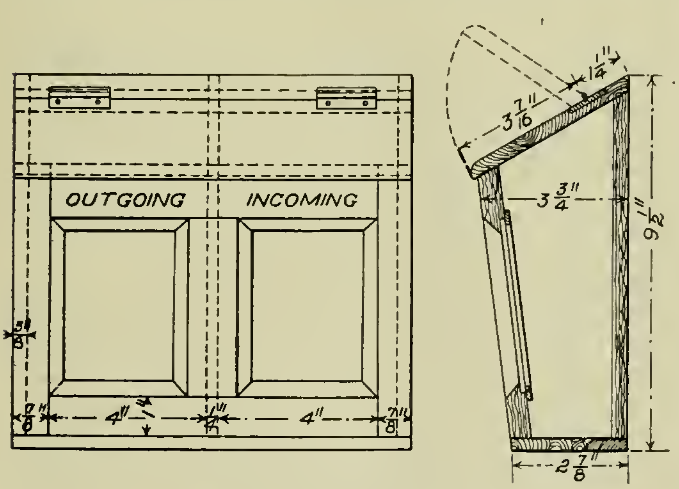
Sanitary Drinking Fountain

hole of a diameter suited to the pressure carried in the water pipe.

A valve, not shown may be placed in the water main and either left open for a continuous flow of water or opened and closed for each individual drinker.

Messenger Box

The Meadville shops of the Erie Railroad make use of a simple messenger box in which is coming and outgoing mail. It is a light box made of wood ⅜ in. thick and is divided into two compartments. In the front of each there is a $3\frac{1}{2}$ in. by $4\frac{1}{2}$ in. pane of glass so that the con-



Details of Messenger Box

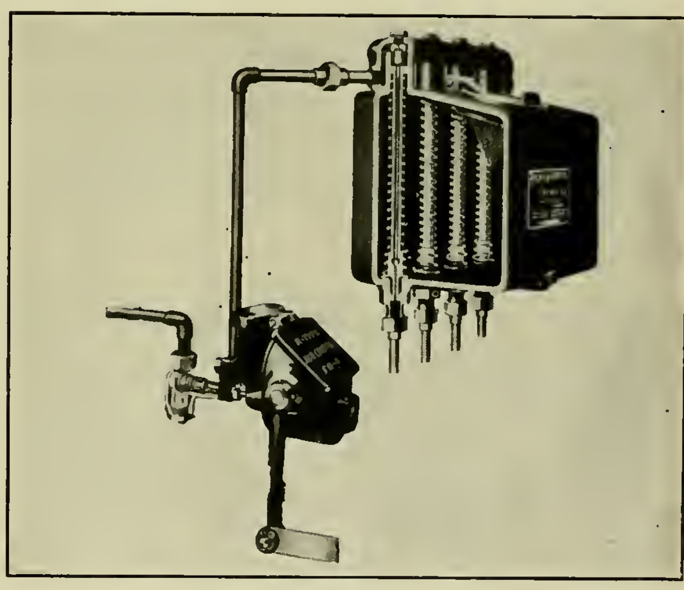
tents or lack of contents can be seen from the outside. There is one hinged cover at the top which extends the whole length of the box, which may be raised for the insertion or removal of the contents. The whole box is but $9\frac{1}{2}$ in. high and 10 in. wide, and can be fastened to the wall, the side of a desk or any convenient place.

Pneumatic Flange Lubricator

The size and weight of practically all rolling stock on railroads having increased greatly in recent years, has resulted in unusual stress and wear upon the wheel flanges and rails, which naturally bear the brunt of all additional poundage. Sharp worn flanges and as a consequence broken flanges spell possible derailments and disastrous wrecks, and involve the expense of turning or replacing tires, and the loss of earning power of the equipment while repairs are being made. It has been apparent for some time that some form of device for properly lubricating the frictional surfaces between wheel flanges and rails should be provided. The proper means of administering oil to a revolving wheel flange has occupied the attention of many mechanical experts for years, and it has been determined that where flange lubrication is properly carried out the life of wheels and rails have been materially extended.

As a safety measure in railroad operation, the flanges of locomotive and car wheels are vital factors. When consideration is given to the heavy power, the high speed and many sharp curves, the wonder is how small flanges will keep the locomotives and cars on the track. In many places the statement has been made that the locomotive and cars tried to take a short-cut across a curve, instead of following the track, whereas with flange lubrication this is not heard, for the reason that with a small amount of oil applied to the flanges or inside head of rails, the hazard of derailments is materially reduced.

A newly devised scheme for effecting the lubrication of



Section Through Hoofer Locomotive Flange Lubricator

wheel flanges of locomotives and cars has been worked out by the Hoofer Mfg. Co., of Chicago, Ill., the device being applied on the locomotives of the Indiana Harbor Belt R. R. and the Chicago Junction R. R., where it has been adopted as standard for all power. In this flange oiler a device has been perfected whereby measured amounts of oil are fed to the wearing surface of the flanges, by air pressure, at regular distances traveled. The oil is not sprayed upon the flanges, but it is gradually released from the oil shoes by an exceedingly small amount of air, which is vented through the oil pipes and acts as a preventive against stoppage in the oil shoes, assuring positive delivery of oil to the wheel flanges at regular intervals.

Air pressure for the operation of the pneumatic flange oiler is obtained through a pipe which has its source in the cab of the locomotive, where it is comparatively free from condensation. A ratchet type air control valve is installed in this air line at a point where its control lever may be connected to the reciprocal movement of the radius bar or valve stem of the locomotive. This ratchet type air control is so designed that its opens and closes the air pressure supply to the lubricator once every hundred revolutions of the driving wheels, at these intervals the air pressure forces the discharge pistons downward into their respective oil cylinders at the bottom of the lubricator, which forces a measured amount of oil from the lubricator, and at the same time causes a vent of air to flow through the discharge pistons, which carries the oil through the oil pipes and the oil shoes to the flanges. When the air pressure is again cut off by the air control valve, the piston springs convoluted about the discharge pistons, return them to their initial positions preparatory to their next lubricating operation. The amount of oil discharged at each interval may be regulated for each wheel separately. The oil cylinders located at the bottom of the lubricator are provided with cylinders of various depths, and are interchangeable, whereby one of the proper capacity may substitute for another to meet the requirements.

This class of lubricating system does not depend upon any care or attention on the part of the engine crew, as there are no valves to be manipulated either before or after the trip. In a sense of common expression the device is fool-proof, as it functions only when the locomotive is in service, and stops when the locomotive is at rest.

The pneumatic venting feature provides a circulation of warm air through the oil pipes and oil shoes, which tends to raise the temperature of the oil in cold weather, and accounts for the success of this device in cold weather in the winter months as well as in summer.

Proper distribution of oil is most essential to successful flange lubrication, and the oil shoes shown in figure 2 have been especially designed for this purpose, the outlet passage for the oil is constantly maintained in contact with that side of the flange which wears against the rail, and thus the oil is supplied in a thin film upon that particular side of the flange where it is most needed. The oil shoes are cast, and are made of a special grade of white iron, which does not wear off rapidly; on the average they will wear from 50,000 to 75,000 miles without renewals. The oil shoes are secured to their hangers by a tempered key, which may be easily removed when it becomes necessary to renew them, and they are held against the wheel flanges in a well balanced position at all times by the hanger springs.

Oil Shoes May Be Applied in Either of the Positions Indicated

An important feature developed in the oil shoe rigging, permits for applying the oil shoes to the wheel flanges in either "incline" or "decline" position, and with the pneumatic venting feature of feeding the oil through the oil shoes, the oil is successfully conveyed to the flanges in either position. The parts comprising the oil shoe rigging are designed so that they may be assembled in various combinations to accommodate various manners in which they are required to be attached to the frame of locomotives of various types, or car trucks and electric power, which may also be in need of flange lubrication.

Snap Shots—By the Wanderer

It is a very good idea that of the Association of Machine Tool Manufacturers, I am a little hazy as to the exact name, but the one given is a good descriptive title of what they are; it is a very good idea, I say, that of charging a dollar for the quotation of a price on a machine tool, to those who wish to use it for estimating or appraisal purposes. But it can be used to excess and leave a bad taste in the mouth. It's like economy of the old rhyme, which says:

"Economy's a very useful broom
"Yet should not ceaseless hunt about the room.
"To catch each straggling pin to make a loom.
"Too oft economy's an iron vice,
"That squeezes e'en the little frames of mice,
"That peep with fearful eyes to ask a crumb."

Like many other rules this can be "more honored in the breach than in the observance."

When an insurance company is asking prices in order to making an appraisal of its losses, or a contractor is making an estimate on a job, it seems quite proper that a charge should be made for the assistance given in the work. But when a railroad company, for example, is going over its property and making an estimate of present values in order to determine either appreciation or depreciation, somehow it strikes me as being a rather small piece of business for the manufacturer to make a charge for giving the present price of a tool that he had sold to the company a year or so before at, presumably, a profit. I have known of a case where a manufacturer sold a tool to a railroad company for $25,000 and two or three years later charged a dollar for naming the, then, present price. Of course the fee was paid without comment, but I happen to know that the impression left by the transaction were so disagreeable that it would militate against this and other firms who did the same thing when new machinery contracts were under discussion.

Such rules that are unimpeachable as guides for general practice should be put out with a good strong string firmly tied to them so that they can be jerked out of sight whenever the special occasion may demand.

There is an old motto of regret, that foresight is not as good as hindsight, that ought either to be wiped off from the slate of mental action or should be so used as to make that good hindsight the guiding star in our preparation for the future. In other words, hindsight ought to be used for the development of foresight. They are trite sayings those, that of history repeating itself, and experience a great teacher, if we will only let it teach.

Procrastination is a great thief of time, but it is also, unfortunately, a most common characteristic of humanity.

In spite of all urging people will not buy their winter's supply of coal in the spring, when "there will be plenty of time" in the fall. Many men wait until their needs are most pressing before they will place an order and, then, when they do, they would like the delivery to be made the day before yesterday, and railroad managers are, by no means, in the exempt class. It is a general experience that traffic grows and as it grows trains must be made longer and locomotives heavier. The past shows it to have been the case and the present shows it to be one of the probabilities of the future.

It is not every mechanical engineer and superintendent of motive power who can design and have built the locomotive or car that is the probability of the future, but there is none so poor in resources or cramped in the expression of his initiative that he can not cast about and calculate what the future has in store and the demands that it is likely to make up on him. And there is never any possibility of taking away his freedom to think. So it is the part of common prudence, in the preservation of his own position, to cast about and see what is likely to be asked of him.

If the rails are light, it may come within his province to suggest that they should be made heavier if train weights are to be increased. Or he may know that he has already reached the limit of weight for the bridges with his present type of locomotive. It may, then, be well to study other types and see what can be done to pull more and make no greater demand on the substructure.

If he is not called upon to make the recommendation that he has prepared he has had the practice of preparing it and the satisfaction of knowing that he was ready for an emergency. If he is called upon his status is increased by his promptness and readiness.

The saying is attributed to Harriman that he had no use for a man who couldn't do as he is told or man who couldn't do anything unless he was told. The applicability of the aphorism holds for every walk of life, superintendents of motive power not excepted.

An old friend of mine used to say that most men liked to wear somebody's uniform, which was merely saying that most of us like to have someone take us by the hand and lead us through life. Someone to take all of the responsibility. The kind of satisfied smack of the lips that accompanies the "well that wasn't my fault" is usually pitiful.

Whether the story of Tom Scott, as a country station agent, setting fire to a wrecked train in order to clear the track and, when it was consumed, telegraphing the fact to headquarters, is true or not, it is a delightful story of willingness to assume responsibility for a possibly unpopular action.

Wendell Phillips once said that freedom was the only way to teach men freedom. So the permission and approval of the exercise of initiative is the best way of having it exercised and of getting the best of service. It is an old religious doctrine that a man is known by his works. This might be paraphrased to read that a man is known by the works of his subordinates. And his subordinates will not repeatedly assume responsibility unless he encourages them to do so.

I heard an interesting story of two successful superintendents of motive power the other day. It related to a time when one was the general foreman of shops for the other. The road was not very flush with power and an engine hauling a fast passenger train had worn its tires to the limit. Could they be changed in the layover time. The general foreman said yes. The S. M. P. said go at it, and the gang was set at work. The tires were replaced but when the general foreman went to inspect he found them too close together, and the time nearly there to take the train. He sized up the situation, looked over some data he had, decided that the engine was safe to run, let it go and said nothing.

He confessed to having kept pretty close track of the train and engine until it returned and then went to the superintendent of motive power, told him the conditions and what he had done.

"Why didn't you tell me before?"

"Well, I was very sure that it was all right and I didn't know that you would be as confident, and I didn't want to worry you. And so decided to take the whole responsibility."

The superintendent of motive power looked at his man, half gasped and said what amounted to the same thing as when the grocer in Little Lord Fountleroy said he'd be jiggered, only this man didn't say "jiggered."

Well the Sunday-school moral came to pass, and the two men were friends for life and general foreman was always ready to assume the full responsibility for all his acts good, bad and indifferent, and somehow people trusted him.

Spring Meeting of the A. S. M. E.

The Railroad Session at the Spring meeting of the American Society of Mechanical Engineers which is to be held in Cleveland, Ohio, May 26th to May 29th inclusive, will be of more than ordinary interest. The topic for discussion at this meeting will be, "Recent Developments in Heavy Electric Locomotives."

Two papers are to be presented on this topic, one by Mr. Norman W. Storer, of the Westinghouse Electric Manufacturing Company, and another by Mr. W. B. Potter of the Railway Department of the General Electric Company.

The development in size and power of electric locomotives in the past few years will be dealt with in these papers and the Society has reason to feel pleased at the prospect of these contributions to the literature of modern motive power. Railway men of prominence familiar with these preliminaries have been invited to discuss these papers.

Railway Fuel Association Convention

The convention of the International Railway Fuel Association, to be held at Hotel Sherman, Chicago, May 26th, 27th, 28th and 29th, will be addressed by R. H. Aishton, President of the American Railway Association, and Charles Donnelly, President of the Northern Pacific Railway. The presence of these executives, who occupy such prominent places in the railroad world, exemplifies the confidence and high regard in which the Association is held by all railroad officials.

W. H. Harris, chairman of the local committee, advises that ample entertainment features are assured through the courtesy of the coal trade, and will include an inspection trip of the new Koppers Chicago coke plant, in addition to many social features. The program of papers is an extensive one, and subjects of particular interest to fuel men will be presented. Following is a tentative list of the subjects to be discussed, and the authors:

"Oil and Coal as Locomotive Fuels," M. C. M. Hatch; "Budget System"; "Fuel Losses at Locomotive Terminals"; "Mining, Preparation and Inspection of Coal for Locomotive Fuel," Malcolm McFarlane; "Main Tracking and Its Effect on Fuel," D. F. Stevens; "Analysis of Report of U. S. Coal Commission," F. C. Tryon. Symposium—Various Coal and Oil Fields: "Northwest Territory," A. W. Perley; "Southwest Territory," J. N. Johnston; "New England States," O. J. Brown; "Ohio, Pennsylvania, West Virginia and Kentucky," R. E. Rightmire; "Other Central States," W. J. Overmire; "Coals of Canada," A. L. Grayburn; "Australian Coals," E. Dillon; "North Dakota Lignite," E. J. Babcock; "Mid-Continent Oil Fields," J. M. Nicholson; "California Oil Fields," W. T. Small; "Mexican Oil Fields," C. S. Pond.

The Atlantic City Exhibit

Applications have been received and space assigned to over 400 exhibitors of the Railway Supply Manufacturers Association for the exhibit which will be held in Atlantic City simultaneously with the conventions of Division V, Mechanical, of the American Railway Association, and Division VI, Purchases and Stores which will be held June 11-18. The exhibit spaces will occupy over 100,000 square feet. In addition there will be special exhibits on track adjacent to the pier by the following concerns: American Locomotive Co., New York. Clark Car Co., Pittsburgh. Dalman, J. W., Chicago. Delaware & Hudson Co., Albany, N. Y., and Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

New Freight Cars and Locomotives

Class I railroads of the United States installed in service 37,652 freight cars during the first three months in 1924, according to reports filed with the Car Service Division of the American Railway Association.

Of that number, 9,923 were placed in service during the month of March.

Cars placed in service during the first three months included 18,317 box cars, 13,783 coal cars and 1,552 refrigerator cars.

The railroads on April 1st also had on order 69,298 freight cars with deliveries being made daily. Of that number box cars on order totaled 31,901, coal cars 18,565 and refrigerator cars 9,255.

Locomotives placed in service from January 1st to April 1st totaled 661, of which 176 were placed in service during the month of March. The railroads on April 1st had 520 locomotives on order.

These figures, both as to freight cars and locomotives, include new, rebuilt and leased equipment.

American Rail Motors on Foreign Roads

Rail motor coaches of American manufacture, in operation on the British section of the Kowloon-Canton railway since 1922 have proved a success. While this equipment, according to the railway official is in the experimental stage, these cars have rendered good service at an economic cost, fulfill the requirements for a light train, for working up new traffic and for development and emergency purposes. The only difficulty encountered in operation has been the delay in securing spare parts and replacements. This should be easily remedied.

The introduction of rail motor cars on the railways of South Australia likewise proved so successful that all the states of Australia may adopt this type of passenger vecle for feeder and short lines in less populous territory. The first 2 of 12 cars ordered from an American company have already arrived and have been installed after successful trial trips. It is said that the Chief Commissioner of Railways plans to purchase about 100 additional rail motor cars for passenger service on the South Australian lines during the next two or three years.

The New South Wales government is experimenting with rail motor cars built in its own shops, but it is understood that the cost is much greater than that of the American cars. The Tasmanian government also has the matter under consideration.

Personal Thrift on the P. R. R.

The Pennsylvania Railroad reports that 3,901 employees have bought shares of the company's stock through the facilities afforded by the Employees' Provident & Loan Association. The stock owned by these employees now amounts to 19,666 shares ($50 a share), which is in addition to the holdings acquired by employees through other channels. The most popular block of stock is two shares, 1,433 employees having become shareholders to that extent. Purchasers of one share number 992; five shares, 549 employees, and ten shares, 350. Of the total of 19,666 shares, 6,686 were bought outright. Over 500 members are purchasing increased pensions through the Association. Savings accounts have been opened by 13,978 members, and their total deposits now exceed $4,000,000. Seventy-nine members are purchasing homes through loans granted by the Association, and these loans now total $275,435.

Notes on Domestic Railroads

Locomotives

The Chesapeake & Ohio Railway is inquiring for 100 heavy and 50 light Mikado type locomotives.

The Seaboard Air Line Railway is reported to be inquiring for 45 locomotives.

The Chicago, Rock Island & Pacific Railway has ordered 10 locomotives from the American Locomotive Company.

The New York, New Haven & Hartford Railroad is inquiring for 15 locomotives.

The Pennsylvania Railroad has issued orders for the construction of 50 suburban type 10-wheel passenger locomotives in its Altoona shops.

The Maine Central Railroad has ordered 8 locomotives from the American Locomotive Company.

The New York Central Railroad is in the market for 3 Mallet type locomotives.

The El Paso & Southwestern System has ordered 6 Mountain type locomotives from the American Locomotive Company.

The Atlantic Coast Line Railway has ordered 20 Pacific type locomotives from the Baldwin Locomotive Works.

The Wilmington, Brunswick & Southern Railway has purchased an oil burning passenger locomotive from the Baldwin Locomotive Works.

The Florida East Coast Railway has ordered 20 Mountain type and 5, 8-wheel switchers from the American Locomotive Company.

The Tennessee, Alabama & Georgia Railway has ordered a Consolidation type locomotive from the Baldwin Locomotive Works.

The Virginian Railway has ordered 12 electric locomotives from the American Locomotive Company.

The Canadian Pacific Railway has ordered 10 locomotives from the Canadian Locomotive Company.

The New York Central Railroad is expected shortly to be in the market for a number of passenger locomotives.

The High Point, Thomasville & Denton Railroad has ordered a freight locomotive from the American Locomotive Company.

The Gary Tube Company has ordered 2 switching locomotives from the Baldwin Locomotive Works.

The Laurenco Marques, Portuguese East Africa, has ordered 4 Mikado type locomotives from the Baldwin Locomotive Works.

Freight Cars

The Chesapeake & Ohio Railway has ordered several thousand freight cars as follows: 1,000 box cars from the Pullman Company; 1,000 hopper and 600 ballast cars from the American Car & Foundry Company; 1,000 hopper from the Newport News Shipbuilding & Dry Dock Company; 1,000 hopper from the General American Car Company; 2,000 hopper from the Standard Steel Car Company; and 500 hopper and 1,000 box cars from the Illinois Car & Manufacturing Company.

The Midvale Steel Company is inquiring for 3 tank cars.

The McMyler Interstate Company is inquiring for 20 arch-bar trucks of 50 tons capacity.

The Detroit, Toledo & Ironton Railroad is inquiring for 10 steel underframe tank cars of 50 tons and 10,000 gal. capacity.

The New York, Chicago & St. Louis Railroad is inquiring for 100 steel underframes for freight cars.

The Reading Company is expected to place an order shortly for 2,000, 70-ton hopper cars.

The Denver & Rio Grande Western Railway is inquiring for 35 automobile cars.

The Union Pacific Railroad will build 93 caboose cars in their own shops.

The Missouri Pacific Railroad has ordered 1,000 automobile cars from the Pennsylvania Car Company.

The Uruguayan State Railways are inquiring for 40 gondola cars.

The El Paso & Southwestern Railway is inquiring for 400 box cars.

The St. Louis Southwestern Railway is reported to be planning repairs to 350 general service cars. This work will be done in its own shops.

The American Steel & Wire Company is inquiring for 20 steel 70 tons gondola cars.

The Florida East Coast Railway is inquiring for 200 box cars, 250 rock box, 100 ballast cars and 20 caboose cars.

The Kansas City, Mexico & Orient Railway is inquiring for 500 box cars, 250 stock cars and 250 gondola cars.

The Bangor & Aroostook Railroad is inquiring for 75 steel underframe flat cars of 40 tons capacity.

The Swift & Company will build 100 stock cars in its onwn shops.

The Missouri Pacific Railroad has placed an order for repairs to 400 gondola cars with the American Car & Foundry Company, 600 box cars with the Sheffield Car & Equipment Co., and will repair 200 gondola cars in their own shops.

The Union Railroad has ordered 500 hopper car bodies from the Greenville Steel Car Works.

The Union Pacific Railroad will build 93 caboose in its own shops at Portland, Oregon.

The Chicago, Burlington & Quincy Railroad has ordered 1,000 stock cars from the Streater Car Company.

The Great Northern Railway has ordered 250 ore cars from the Bethlehem Steel Company.

The Western Electric is inquiring for a number of special flat cars.

The Richmond, Fredericksburg & Potomac Railway has ordered 15 ballast cars from the Rodger Ballast Car Company.

The American Refrigerator Transit Co., is inquiring for 2,000 refrigerator cars.

The Union Refrigerator Transit Co. will build 250 refrigerator cars in its own shops.

The Central of Brazil is inquiring through the car builders for 50 refrigerator cars.

The Chicago & Northwestern Railway has ordered 1,000 miscellaneous car parts from the Ryan Car Company.

The Canadian Pacific Railway will build 500 freight cars in their Angus Shops at Montreal. .

The Southern Railway has placed an order for 250 gondola cars with the Chickasaw Shipbuilding & Car Co. This order is in addition to the 1,250 recently placed with the same company.

Passenger Cars

The Atchison, Topeka, & Santa Fe Railway is inquiring for 20 baggage cars.

The Nashville, Chattanooga & St. Louis Railway is inquirin gfor 3 coaches and 4 baggage cars.

The Morrissey, Fernie & Michel Railway, British Columbia, has ordered a 30 passenger motor car and trailer from the Edwards Railway Motor Car Company. ·

The Chesapeake & Ohio Railway has ordered 15 express cars from the Pressed Steel Car Company.

The Atchison, Topeka & Santa Fe Railway has ordered the following passenger equipment from the Pullman Company, 10 smoking cars, 10 three compartment cars, 10 chair cars, 10 coaches and 10 postal cars.

The El Pason & Southwestern Railway has ordered 3 coaches and one diner car from the American Car & Foundry Company.

The Duluth, Missabe & Northern Railway has ordered one motorized car from the Oneida Manufacturing Company.

The New York Central Railroad is inquiring for 28 horse cars.

The Pennsylvania Railroad has ordered 12 standard all steel dining cars to be built at its own shops at Altoona, Pa.

The Chicago, Burlington & Quincy Railroad has ordered six baggage mail cars from the American Car & Foundray Company.

The Florida East Coast Railway is in the market for 3 coaches.

The Northern Pacific Railway has ordered 10 steel baggage cars from the Pullman Company.

The Southern Pacific Company has ordered 4 coaches, 5 chair cars and 4 baggage-mail cars from the Standard Steel Car Company.

The Blue Ridge Railway has ordered 2 model 55 gasoline cars from the J. G. Brill Company.

The New York, Chicago & St. Louis Railway has ordered 4 mail-express cars, 3 baggage-express cars and 5 coaches from the Pullman Company.

The Boston & Maine Railroad has ordered one passenger and baggage gasoline car from J. G. Brill Company.

The Gulf, Mobile & Northern Railway has ordered 2 model 55 gasoline cars from the J. G. Brill Company.

The Florida East Coast Railway is inquiring for one dining car.

The Southern Pacific Company has ordered 10 interurban cars from the Pullman Company.

The Chicago, Rock Island & Pacific Railway has ordered 8 diners and 5 buffet baggage cars from the Pullman Company.

The Virginian Railway has ordered a business car from the Bethlehem Company.

The New York Central Railroad has ordered 10 steel passenger cars from the American Car & Foundry Company.

The Argentine State Railways are inquiring through the car builders for 3 dining cars and 3 kitchen cars.

The Atchison, Topeka & Santa Fe Railway has ordered 6 business cars from the Pullman Company.

Buildings and Structures

The Louisville & Nashville Railroad is preparing plans covering the construction of a roundhouse and shops at Leewood, Tenn.

The Minneapolis & St Louis Railway is having plans prepared covering improvements to its locomotive repair shop and engine house at Oskaloosa, Iowa.

The blacksmith shop, machine shop, tin shop and storage house of the Missouri Pacific Railroad at Fort Scott, Kansas, were destroyed by fire on April 16th.

The Southern Railway has awarded a contract for the construction of a roundhouse and flue shop at Spencer, N. C.

The Northern Pacific Railway is reported to have awarded a contract covering the construction of a boiler shop at Livingston, Mont.

The Great Northern Railway is reported to be planning the construction of a 72 stall roundhouse at Hillyard, Wash.

The Chicago Northwestern Railway will build machine shops at Norfolk, Nebr., this spring.

The Pennsylvania Railroad is planning the construction of a new roundhouse and repair shop at Franklin, Pa., to replace the structure at Oil City, Pa., recently destroyed by fire.

The Chicago, Milwaukee & St Paul Railway is planning to enlarge its shop facilities at Tacoma, Wash.

The Wrightville & Tennile Railroad, it is reported, plans the construction of the following shops: Locomotive, machine, carpenter, blacksmith, paint, etc., at Dublin, Ga., to cost approximately $75,000.

The Chicago, Burlington & Quincy Railroad is reported, will improve and rebuild their engine terminal at Gibson Yards, Omaha, Nebr.

The Canadan Pacific Railway is reported to be planning the construction of a roundhouse at Schreiber, Ont., to cost approximately $150,000, replacing the one recently destroyed by fire.

The Southern Railway plans a 37-stall roundhouse, flue and babbitt shops, 100 ft. turntable and other shop facilities at Spencer, N. C.

The Lehigh & New England Railroad is planning the construction of a locomotive repair shop, a roundhouse and machine shops at its yard near Tamaqua, Pa., to cost approximately $100,000 with equipment.

The Canadian National Railways will start construction this spring of improvement to its roundhouse at Stratford, Ont.

The Delaware, Lackawanna & Western Railroad is having plans prepared covering large additions to its roundhouse at Binghamton, New York, estimated to cost $130,000 with equipment.

The New Orleans Public Belt Railway is inquiring for bids covering the construction of engine terminals at New Orleans, La.

Items of Personal Interest

P. E. Crowley, formerly vice-president in charge of operation of the New York Central, has been elected president and a director succeeding the late A. H. Smith.

Mr. Crowley came up through the ranks and has built a reputation as one of the ablest railroad operating officers in the world. He is a tremendous worker, but noiseless in operation. Perhaps his next most important characteristic is his unlimited patience and persistence. He understands the theory and practice of railroading down to its most minute detail and is observant to a most embarrassing degree. As a dispatcher he was a member of the Order of Railroad Telegraphers and still retains his card. It is said of him that he still retain the friendships of those lower down in the ranks and is personally acquainted with the men on the road.

Mr. Crowley was born on August 25, 1864, and entered railway service in 1878, as a telegraph operator on the Erie Railway. From August, 1885 to February, 1889, Mr. Crowley was train dispatcher of the same road; February, 1889, to May, 1890, train dispatcher, New York Central & Hudson River R. R.; May, 1890, to August, 1891, chief train dispatcher; August, 1891, to September 12, 1900, trainmaster; September 12, 1900 to August 24, 1901, chief trainmaster; August 24, 1901, to December 26, 1904, superintendent, Pennsylvania division; December 26, 1904, to March 1, 1907, assistant general superintendent at Syracuse, N. Y.; March 1, 1907, to April 15, 1912, assistant general manager at Albany, N. Y.; April 15, 1912, to December 23, 1914, general manager, New York City; December 23, 1914 to January 1, 1915, assistant vice-president in charge of operation; January 1, 1915, to September 14, 1916, assistant vice-president in charge of transportation and equipment maintenance; September 14, 1916, to June 10, 1918, vice-president in charge of operation; June 10, 1918 to March 1, 1920, federal manager New York Central R. R., Lake Erie & Pittsburgh R. R., Central New York Southern R. R., Troy Union R. R., and Cherry Tree & Dixonville R. R. On the return of the roads to the owners on March 1, 1920, Mr. Crowley was appointed vice-president of the New York Central R. R., Ottawa & New York Ry., Adirondack & St. Lawrence R. R., Raquette Lake Ry., and Fulton Chain Ry., and, in 1922, he was also appointed vice-president of the Toledo & Ohio Central Ry., Kanawha & Michigan Ry., Kanawha & West Virginia R. R. and the Zanesville & Western Ry., in which capacity he was serving until the time of his appointment.

P. E. Crowley

T. J. Clayton has been appointed master mechanic of the Texarkana & Ft. Smith Railway with headquarters at Port Arthur, Tex., succeeding **A. D. Williams**, assigned to other duties.

Albert L. Hafner has been promoted to assistant shop foreman of the Mt. Clare shops of the Baltimore & Ohio Railroad with headquarters at Baltimore, Md.

W. A. Bender, general foreman of the Chicago, Milwaukee & St. Paul Railway with headquarters at Green Bay, Wis., has been appointed superintendent of shops of the Missouri Pacific with headquarters at St. Louis, Mo.

W. A. BeDell, general master mechanic of the Missouri Pacific Railroad at St. Louis, Mo., has been assigned to the Lines West and St. Louis Terminal division west of the Mississippi River.

Arley Hay has been appointed assistant roundhouse foreman of the Kansas City Southern Railway with headquarters at Pittsburgh, Kansas.

Major James G. Steese, U. S. Army, who has been serving as chief engineer of the Alaska Railroad has retired with the appointment of general manager.

W. R. Kennedy, assistant master mechanic in charge of the rebuilding of locomotives at the Montreal Locomotive Works has been appointed to fill newly created position of assistant mechanic of the Wabash Railway with headquarters at Peru, Ind.

J. Dietrich, master mechanic of the Lincoln division of the Chicago, Burlington & Quincy Railroad, with headquarters at Lincoln, Nebr., has been given extended jurisdiction to include the Omaha division. The position of master mechanic at Omaha has been abolished.

C. F. Craft has been appointed general foreman of the Southern Railway at Atlanta, Ga., succeeding **H. G. Stubbs**, promoted.

L. D. Freeman, assistant to manager Mechanical Department of the Seaboard Air Line Railway, with headquarters at Norfolk, Va., has resigned to become assistant to the chief mechanical officer of the Chesapeake & Ohio Railway with headquarters at Richmond, Va.

T. L. Mallam, foreman of the Trenton Boiler shops of the Pennsylvania Railroad has been appointed foreman of the Juanita boiler shop at Altoona, Pa., succeeding **T. J. McKerihan**.

A. C. Melanson has been appointed acting superintendent of the St. Malo shops of the Canadian National Railways.

George Hain, formerly general roundhouse foreman of the Chicago Great Western Railroad at Oelwein, Iowa, has been appointed acting shop superintendent with the same headquarters. **B. H. Werdel**, formerly machine shop foreman has been appointed general roundhouse foreman with the same headquarters, succeeding **Geo. Hain.**

D. W. Cunningham, general master mechanic of the Missouri Pacific Railroad with headquarters at Little Rock, Ark., has been assigned to the Lines South, St. Louis Terminal east of the Mississippi river, Illinois division and North Little Rock and the Sedalia back shops.

Supply Trade Notes

The American Car & Foundry Company has acquired the plant of the Pacific Car & Foundry Company at Portland, Oregon, and Seattle, Wash. The value of the two plants is set at approximately $900,000 including machinery.

The Sellers Manufacturing Company has moved its Chicago general sales offices from the McCormick Building to 1927 Illinois Merchants Bank Building.

The Universal Locomotive Company, Chicago, Ill., has been incorporated by **Darrell S. Boyd, Roy P. Kelly** and **Glen A. Lloyd.**

The Union Switch & Signal Company has moved its New York office from 165 Broadway to the New Westinghouse Building at 150 Broadway, New York City.

The Youngstown Steel Car Company has opened a new district office in the Canadian Pacific Building, New York City, in charge of **John H. McCartney**, formerly representative at New York for the Standard Tank Car Company.

The National Acme Company, Cleveland, Ohio, announces the following: **N. W. Foster**, formerly assistant secretary and treasurer, has been appointed vice-president and general manager with headquarters at Cleveland, and **Clarence P. Kramer** has been appointed sales representative in the St. Louis territory.

The T. H. Symington Company has moved its Chicago offices to 2108 Straus Building, 310 So. Michigan Avenue.

The Sykes Company has moved its general office at Kenosha, Wisc., and its plant at Winthrop Harbor to St. Louis, Mo., where the general offices are located in the Liberty Central Trust Building.

J. F. Whalen, who has represented **Manning, Maxwell & Moore** for a number of years in eastern Pennsylvania has resigned recently.

C. A. Paquette, chief engineer of the Cleveland, Cinncinati, Chicago & St. Louis Railway, with headquarters at Cincinnati, Ohio, has been appointed president of the **M. E. White Company**, with headquarters at Chicago, Ill.

The Ward Railway Equipment Company, of Lima, Ohio, plans the removal of its offices at Delphos, Ohio, according to an announcement made by J. F. Ward, president.

The Zapon Leather Cloth Company has moved its New York offices from 5th Avenue to the Park-Lexington Building, Forty-sixth St. and Park Avenue, New York City.

L. M. Kilgore has been placed in charge of engineering work at the **General Electric** transformer plant at Oakland, Calif. Mr. Kilgore was formerly at the Pittsfield plant of the General Electric Company.

The Westinghouse Air Brake Company has moved its New York office from 165 Broadway, to the new Westinghouse

Building which has just been completed at Broadway and Liberty Street, New York City.

W. J. Roehl has been appointed a sales agent in the railway department of the **Newport News Shipbuilding & Dry Dock Company,** with headquarters in the Railway Exchange Building, St. Loults, Mo., and **J. S. Sheafe** has been appointed sales agent with headquarters at 7356 Woodlawn Avenue, Chicago, Ill.

John H. Wynne has been appointed manager of the **Lima Locomotive Works,** Lima, Ohio. Mr. Wynne was formerly connected with the General Equipment Company, and prior to that was with the American Locomotive Company.

Willis C. Lincoln has been appointed western sales manager of the **Electric Service Company,** with headquarters at Chicago, Ill. Mr. Lincoln was formerly connected with the National Railway Appliance Co., New York City.

The American Frog & Switch Company, Hamilton, Ohio, has discontinued its New York office. The Pittsburgh office of the company will take over the sales formerly handled by the New York office.

Edwin W. Allen, assistant district manager of the **General Electric Company** at Chicago, has been promoted to manager of engineering with headquarters at Schenectady, New York.

The Tank Car Gauge Co., Pittsburgh, Pa., has been incorporated by **C. F. Ehrentraut** for $100,000.

D. S. Wood has been appointed district sales manager of the **Niles Bement Pond Co.,** with headquarters at Chicago, Ill., succeeding Samuel Eastman.

G. C. Richards has been appointed eastern representative of the **National Engineering Company,** Chicago, Ill., with headquarters at Philadelphia, Pa.

The General Electric Company is taking bids covering the construction of a five-story building at Detroit, Mich., to house its offices, warehouse and shops. It will be steel and reinforced concrete throughout and is estimated to cost $300,000.

Howard Jackson has been appointed district manager of the **Brown & Sharpe Manufacturing Co.,** Providence, R. I., with headquarters at Chicago, Ill.

The Central Brake Shoe & Manufacturing Company, Chicago, Ill., has increased its capital stock from $120,000 to $150,000.

S. F. Taylor, of the **S. F. Bowser Company,** Fort Wayne, Ind., has been appointed eastern representative of its railway sales division. Mr. Taylor has held many responsible positions with the Bowser Company over a period of fifteen years. He will have contact with all railroads having offices in New York City and other eastern points.

The Ohio Injector Company, Wadsworth, Ohio, plans the construction of a factory addition to be three stories and basement and estimated to cost $200,000.

The Prime Manufacturing Company, Milwaukee, Wisc., plan the rection of a new brass foundry and machine shop.

The Westinghouse Air Brake Company announces a change of address of its New York City office on May 1st, from the G. Benenson Investing Building, 165 Broadway, to the new Westinghouse Building which has just been completed at 150 Broadway. The entire 23rd floor will be occupied by the Air Brake offices. **The Locomotive Stoker Company** and the **Union Switch & Signal Company,** subsidiaries of the Westinghouse Air Brake Company, will occupy the 22nd floor. **The Westinghouse Electric & Manufacturing Company,** with its various subsidiary and associated companies, will occupy 10 floors. The floors below the 12th will be occupied by concerns other than the Westinghouse companies.

Obituary

Harvey S. Patterson, Manager of the Railroad Department of the Walworth Manufacturing Co., Boston, Mass., died on April 6, at the Norfolk County Hospital, Mass., at the age of 38. Mr. Patterson was with the Kewanee Works of the Western Tube Works, and when the Walworth Manufacturing Co., took over the Kewanee Works, he organized the Railroad Sales Department, introducing the Kewanee Union and other Walworth specialties to railroad buyers and users.

Leigh Best, senior vice-president of the American Locomotive Company, died on April 27, in Roosevelt Hospital, New York following a surgical operation. Mr. Best had been connected with the American Locomotive Company since its organization in 1901.

T. W. Snow, president of the T. W. Snow Construction Company, Chicago, died suddenly at his home in Batavia, Ill. on April 20, at the age of 56. Mr. Snow entered railway service in 1876 in the employ of the Chicago & North Western Railway. In 1885 he entered the employ of the Pennsylvania Steel Co. From 1888 until 1898 he was in charge of the Railway Department of the U. S. Wind Engine & Pump Co., Batavia, Ill. In 1898 he was appointed western manager of the Railway Department of the Otto Gas Engine Co., with headquarters in Chicago, and in 1906 was elected president of the company. In 1911 he organized and became president of the T. W. Snow Construction Co., Chicago, which position he held until his death.

Sanford Keeler died at his home in Saginaw, Mich., on March 18. Mr. Keeler was in his 86th year. He began his railroad career in 1860 with the Flint & Pere Marquette Railroad now part of the Pere Marquette System. He was engineer of the first locomotive of the Pere Marquette and built the road's line westward to the shores of Lake Michigan. After leaving the Pere Marquette in 1891 he helped to build several other railroads and took a part in the operation of the old electric interurban line between Saginaw and Bay City, Mich. Subsequently, he became identified with the railway supply and equipment companies, and was for many years western representative at Chicago for the Nathan Manufacturing Co., New York.

Dr. Wilhelm Schmidt

Dr. Wilhelm Schmidt, whom *Die Locomotive* characterizes as one of the greatest pathfinders in German technical work, the founder of the Schmidt Superheater Works at Cassel, died in his sixty-seventh year, after a long and severe illness at Bethel near Bielefeld, Germany, on Feb. 16.

Dr. Schmidt was born on February 18, 1858, at Wegeleben near Halberstadt and was the only son of a farmer, and it was there that he attended the common school. He manifested an inclination for technical work at an early age, and at Wegeleben and Halberstadt he learned the trade of a locksmith, and then went out as a journeyman. It happened that in Dresden, in consequence of his skill as a workman, he became acquainted with a well-known artist, the painter Professor Ehrhardt, who was a teacher in the art school at that place. Professor Ehrhardt recognized his extraordinary ability, and introduced him to Prof. Zeuner who was at that time the director of the Dresden Technical High School. Through Zeuner he became acquainted with Prof. Lewicki, who was also connected with the high school and who took him up with the greatest interest and forwarded his technical education. It is very remarkable that Schmidt never took kindly to mathematical formulæ, but always went in a simple, straightforward manner to the solution of the most difficult problems of thermo-dynamics by self-confident mental calculations and original rules, in such a way as to frequently astonish his fellow-workers by his scientific attainments.

Dr. Wilhelm Schmidt

He was scarcely twenty-five years old when he established himself independently in Brunswick, and took up the improvement of the heat engine as his life's work. One of his first designs was for a small industrial motor that was needed by hand workers, for the electric motor had not yet come into existence. As a result of this work, he first developed a machine using a mixture of hot air and steam, and finally a steam engine using highly superheated steam. The investigations with superheated steam went deeply into the fundamentals of the steam engine. He was greatly influenced by the work of Hirns of Mulhausen in Alsace, whose scientific research went most thoroughly into the subject.

It must be remembered that as far as practical work, up to that time it was only dry saturated steam that such well-known locomotive designers as Von Borries and Goldsdorf were attempting to obtain with their compound constructions.

It was in 1891 at the works of Beck and Henkel in Cassel, that after eight months of experimental work a complete revolution was made in steam engine construction. This also resulted in Schmidt's settling at Wilhelmslohe, where under the patronage of Director Henkel, he received further assistance in the prosecution of his work. Today there is scarcely a new steam power plant built in Germany that is not equipped to use highly superheated steam.

In the first Schmidt compound superheated steam engine, working with a condenser, which was a further improvement of the first machine, and which was also built by Beck and Henkel, the extraordinarily favorable results were obtained in 1894 of the development of a horse power on a steam consumption of 9.9 lbs. per hour. A result which aroused the intensest interest throughout the scientific world, for up to that time the best steam engine of the same size, consumed about twice that amount of steam.

Schmidt's creation of the superheated steam locomotive was a matter of great economic importance to the world. There are today more than 100,000 locomotives that are using superheated steam. For instance, a coal saving of from 15 to 30 per cent., in this field through the application of superheated steam, means an increase of locomotive tonnage hauled of about 50 per cent. Schmidt's invention was one of the greatest advances that has been made in locomotive construction since Stephenson. The Schmidt superheated steam locomotive made possible a simplification in construction. The locomotives could be made simpler, and shorter, and therefore, lighter and above all it became possible, with a simple two-cylinder machine, to perform the maximum amount of work. Who can imagine the gigantic American locomotives working with saturated steam? It would hardly be possible to provide the grate area needed for the horse power developed.

The epoch-making point in locomotive building brought about by Schmidt's superheater can be best illustrated by the boiler construction. For example; take the steam pressure that had been previously in use. It was often possible to lower it so that in Austria it was reduced on some engines to 160 lbs., and in Germany it was often lowered to 175 lbs. per sq. in., though because of the increased demand for greater power it was raised during the next one or two decades from 205 to 220 lbs. per sq. in.

A single example will make the value of the Schmidt design very plain.

It is well known that the Northern Railway of France runs the fastest trains in Europe and it has the finest express locomtoives. Forced by the increasing demands of the heavy express service, there was developed the latest type of four-cylinder compound saturated steam locomotive with a steam pressure of 265 lbs. per sq. in.; the difficulties encountered in service and performance could not be met by a smaller locomotive. They then applied superheated steam, reduced the Baltic type to the compound and kept the same pressure. When asked in regard to a further increase, M. Asselin, who was at that time the head of the locomotive department, wrote in 1913 that: "with the Schmidt superheater we have everything." In fact a light locomotive with a smaller firebox was designed later to meet the conditions of the service. This engine attained an average speed of 62 miles an hour from Paris to St. Quentin with a train of 400 tons and on a grade of about .5 per cent.

Nearly all new locomotives are fitted with superheated steam, only the very small type use saturated steam.

It is hardly worth while to set forth the necessity of going to a higher steam pressure in locomotive construction, for Schmidt has already shown the way.

The last twelve years of Wilhelm Schmidt's career was occupied with the introduction in stationary engines of such high steam pressures as 880 lbs. or more per sq. in. He had already started this work as a young man in 1885, but up to the present time, the solution of the problem has not been reached from a practical standpoint.

The first public announcement of the progress of the work and investigations of Wilhelm Schmidt on high pressure steam was made at the meeting of the Society of German Engineers at Cassel in June, 1921. The rather unprecedentedly low steam consumption known up to that time per indicated horse power hour was stated to be about 5.5 lbs. in steam engines of 150 horsepower. This aroused most unusual interest for the apparent unsuitability of raising steam pressure rests upon a false basis both in theory and practice. After a lapse of scarcely three years, it appears that in the future large steam plants will be built to work under pressures of 600, 700, and even as much as 1,500 lbs. per sq. in., which will be but a further development of the steam engine along lines introduced by Wilhelm Schmidt.

Schmidt was a modest, retiring man up to the end of his life. None of the many distinctions that were showered upon him could bring him out of his retirement. He talked freely about his work. He always had an open hand and a kind word for the poor and needy. His commanding nature did not commend him to the wide public popularity. He was no orator and avoided public appearances. He was a pronounced student and artist by nature. In his volcanic working spirit there existed a creative faculty, that was often first brought to the light of day after long effort. His geniality was especially manifested within the narrow circle of his friends and fellow workers on fitting occasions. There was no one who came into close contact with Schmidt who was not influenced by his strong personality. He was penetrated with a deep piety and held fast to the faith that he would be saved by a gracious God, and that humanity would be helped by his work.

The unexpected outcome of the war had an extraordinarily depressing effect upon him. He tormented himself with the problem as to how he could help his country. The opinions and developments connected with it, as well as the agitation resulting therefrom, was undoubtedly the cause of his last severe illness from which he is now dead.

The whole scientific world mourns his loss.

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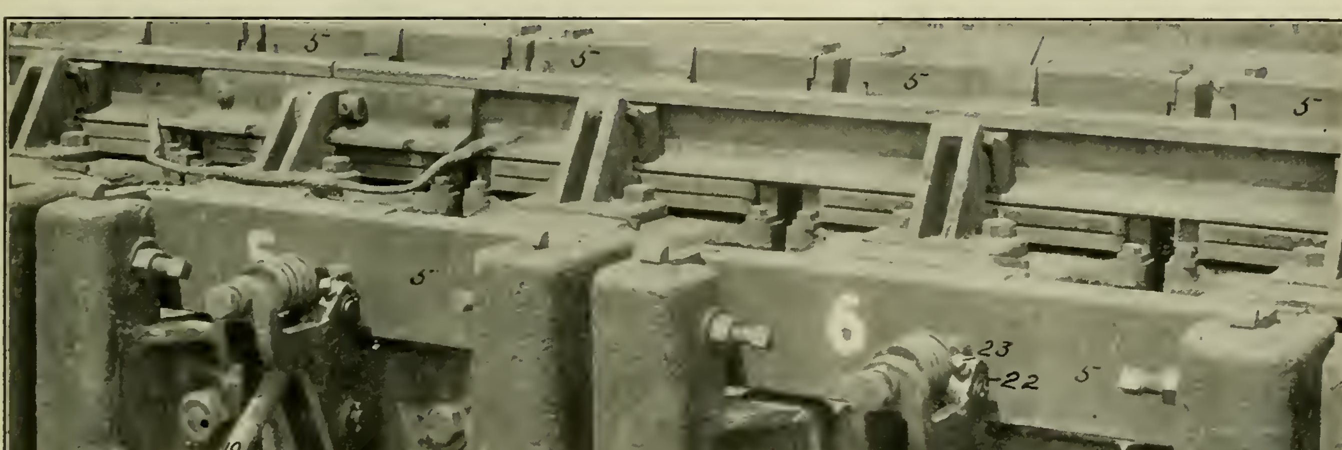
The Otheograph of the General Electric Company

An Instrument Designed to Measure the Lateral and Vertical Stresses Imposed on Rails

In the April, 1920, issue of RAILWAY LOCOMOTIVE ENGINEERING there was published a description of an electric locomotive designed and built by the General Electric Co. for the Chicago, Milwaukee & St. Paul Ry. Since that time that locomotive has run more than 400,000 miles without having received a general or backshop overhauling and the commutators are as smooth and perfect as when they first left the shops on the new machine. This condition of the commentators is attributed to the quick acting circuit breakers that are used. These circuit breakers act in from one five-thousandth to one ten-thousandth of a second, or in less time than it takes



Two Otheograph Units Showing Arrangement of Recording Pens and Cylinder two adjacent commutator sections to pass beneath the brushes when the engine is running at speed.

It is because of this phenominal record that the locotive has recently been exhibited through the middle west and east and a demonstration of its action was again made on the experimental track of the General Electric Co. at its works in Erie, Penna.

This demonstration was made on May 19 and at the same time there were others related thereto. These included the exhibition of the electric locomotive; of a multiple unit train working with a 3,000-volt direct current, a a demonstration of a high current collection with the pantograph; the action of the hornless pantograph; a steam locomotive hauling the electric locomotive regenerating; and the taking of the otheograph records.

In the current collection or absorbtion demonstration, 4,000 amperes were taken off the wire at a speed of 60 miles per hour, the feed wire having a slope of 1 per cent. In another demonstration 5,000 amperes were taken off at the same speed, the feed wire having a slope of ¾ per cent.

At the time of the previous demonstration in 1920, there was a single example of the otheograph or thrust recorder in the track. The instrument was in an imperfect condition and in process of development at the time, so that no attempt was made to obtain a record of the action of the locomotives.

The instrument has now been perfected and an installation of twenty-five has been made on a tangent track.

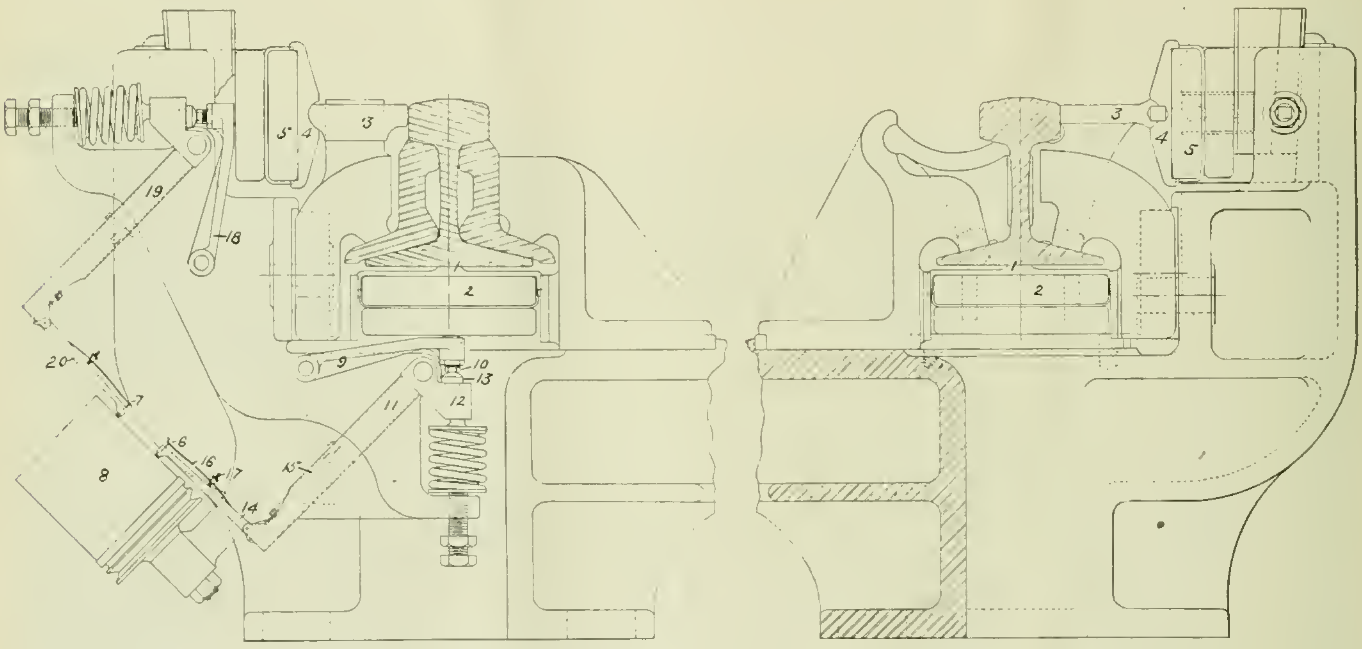
The otheograph is a device for recording the action on the rails of each wheel of a locomotive or car, and shows by the amplitude of the movement of the recording stylus the relative intensity of the vertical and lateral thrust of each wheel on each tie, as indicated by the deflection of the rail. The vertical deflection is transmitted through heavy springs underneath the rail, and the lateral deflection through similar springs that are set vertically and have a bearing against the head of the rail. These deflections are recorded through a lever arm by means of a stylus, which traces the record on a paper wrapped around a rotating cylinder in the same manner as in the case of a steam engine indicator.

The otheograph unit comprises a metallic tie and the apparatus for making the record at each end thereof. They may be installed in the place of the regular ties, either singly or several together, and on curves or tangent track.

The record from a slowly moving locomotive shows the equalization of the weight distribution, and such a record serves as basis of comparison with those taken at high speed.

The effect of the lateral thrust on the vertical component and any variation, due to dynamic unbalance, are quite noticeable. The effect of a wheel with a flat spot is also clearly shown.

As already stated the installation at Erie consists of twenty-five ties set on a tangent track and was illustrated in the December, 1923, issue of RAILWAY AND LOCOMOTIVE ENGINEERING. Particular attention was given, in this installation to the obtaining of the same type of roadbed as on the rest of the track. Each otheograph tie is located immediately over a wooden tie with the same supporting ballast as elsewhere, and they are spaced 2 ft. apart from center to center. Between the otheograph tie and the wooden tie, there is a thin wooden stringer to retain the alinement, but which has no appreciable vertical stiffness; and, as far as observation shows, the action of a locomotive in running over the apparatus imposes no unusual track conditions.



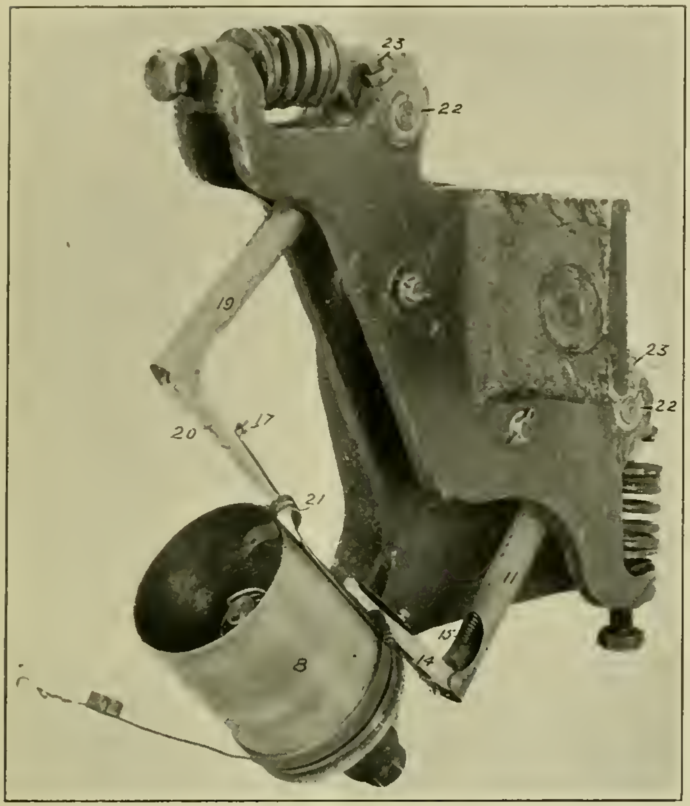
Longitudinal Section of Otheograph

The construction of the device will be readily understood from an examination of the engravings. In this case the track is laid with rail weighing 100 lbs. to the yard, and is carried on a clip (1) having a central rib on which the rail rests on a point immediately beneath the web; the clip itself resting on the supporting springs. So, while the rail has a direct vertical support, it is free to tilt sideways insofar as this supporting clip is concerned. The spring (2) is formed of two plates about ¾ in. thick and slightly wider than the base of the rail. The plates rest, at their ends on the body of the tie which is a steel casting of the shape clearly shown in the reproduction of the photograph.

The lateral thrust is taken at the center of the space spanned, and is carried by the strut (3) to the clip (4) which is attached to the outer plate (5) of the spring.

The vertical movement of the spring (2) is carried by a combination of levers to the stylus (6) which bears against a strip of metallic paper that is rolled on the drum (8).

This combination of levers has been very carefully worked out so as to transmit the movement of the rail to the stylus without any loss and in a ratio of eight to one.



Levers for Operating Pens and Cylinders of Otheograph

In the case of the vertical movement an arm (9) is pivotted to the body of the tie and carries a pin (10) having a spherical upper end that is in contact with the bottom of the spring, and flat lower end, that rests against the spherical end of a pin (13) that is carried in the short arm of the bell-crank lever (11).

This bell-crank lever is also pivotted in the body of the tie casting, and its trunnions turn in split bushings (22) and these, in turn, can be pinched in on the trunnions by a set screw (23) so that a desired frictional resistance to the movement of the lever may be set up.

The pin (10) has a screw adjustment, and the whole is kept up against the spring (2) by a light helical spring, whose tension can be adjusted from below by the adjusting screw, that is threaded into a bracket extending down from the main body of the tie.

At the lower end of the bell-crank lever (11) the arm carrying the stylus is pivotted. This arm is held up to its operating position and against a stop by a helical spring (15). Or it may be turned back through about 90 degrees when the connection of the spring (15) is carried past the center and the arm and stylus will be held away from contact with the paper on the drum.

As for the stylus, itself, it is held gently pressed against the paper by a flat spring (16), that pressure being adjusted by a thumb screw (17).

The lateral movement of the spring (5) is carried, in a similar manner to the stylus (7) through the arm (18) the bell-crank lever (19) and the arm (20) that carries the stylus.

It will thus be seen, that any downward movement of the spring (2) is indicated by an upward movement of the stylus (6) and any outward lateral movement of the spring (5) is indicated by a downward movement of the stylus (7).

The paper used on the drum has a metallic coated surface and is held in place by the clips (21) after the manner of a card on a steam engine indicator, the line being drawn by a brass stylus.

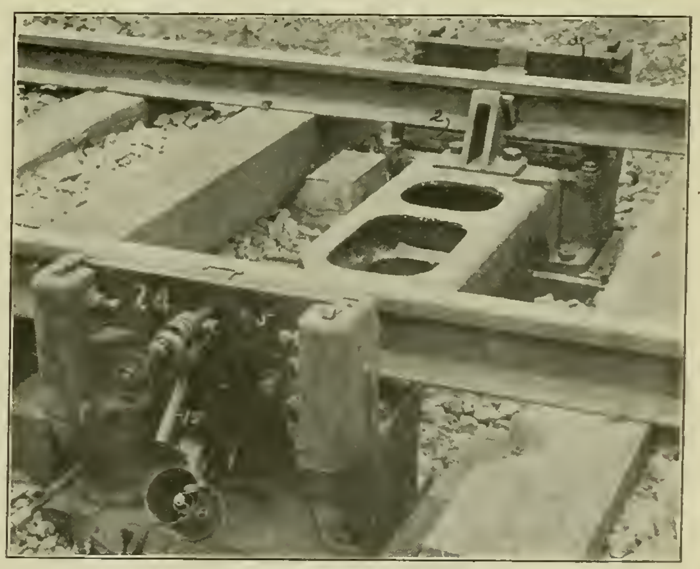
This means that, when records are to be taken, the rotation of the drum must be limited to less than a full revolution.

The drum is similar to, though larger than, that of a steam engine indicator. It is rotated by a string and returned by a spring in the same way.

In order that all of the drums of the installation may be rotated in unison, the strings are attached to a bar (24) which is carried on and between rollers. This bar is moved to the left at a uniform speed by an electric motor located in a nearby shelter.

The method of operation is to start the motor just before the vehicle to be investigated reaches the apparatus, and stop it when the last wheel is clear of the same, the speed being regulated in accordance with the speed of the car or engine. The higher the speed the faster the paper is moved. The principal feature being the uniformity of motion obtained so that all records become comparable.

According to the calibrations that have been made of the apparatus the pen recording the vertical movement, the stress amounts to 50,000 lbs. to the inch, and for the horizontal movement it is 32,000 lbs. to the inch. These calibrations were made in the track with the apparatus in place, so that it includes the bending of the running rail as well as the resistance of the springs. The question naturally arises as to whether the units near the end of



Single Otheograph Unit Complete

the installation will offer the same resistance as those near the center, because of the rigid support which the rail receives on the approach track. It has been found that the difference in these registrations between the end and center units is so small as to be undetectable and negligible.

At the demonstration on May 19, two locomotives were run over the otheograph at 10 and over 60 miles per hour and records of the pressures developed obtained. These engines were a Mikado owned by the New York Central, and the Chicago, Milwaukee & St. Paul electric.

The general dimensions of the Mikado were as follows:

Cylinder diameter	28 in.
Piston stroke	30 in.
Diameter driving wheels	63 in.
Diameter truck wheels	33 in.
Firebox length inside	114⅛ in.
Firebox width inside	84¼ in.
Grate area	66.4 sq. ft.
Tubes, number	253 3¼ in.
Tubes, length over sheets	20 ft. 0 in.
Heating surface tubes	4287 sq. ft.
Heating surface firebox and arch tubes	291 sq. ft.
Total heating surface	4578 sq. ft.
Heating surface superheater	1780 sq. ft.
Weight on front Truck, working order	29000 lbs.
Weight on Drivers, working order	248000 lbs.
Weight on rear Truck, working order	58000 lbs.
Total wt. of Engine, working order	335000 lbs.
Weight of Tender, loaded	200300 lbs.
Weight of Tender, empty	85000 lbs.
Steam Pressure	210 lbs.
Max. Tractive Force, Engine	66640 lbs.
Tractive Force Booster	10700 lbs.
Combined Tractive Force, Engine and Booster	77340 lbs.

The dimensions of the electric locomotive were:

Length over all	76 ft.
Length of wheel base	67 ft.
Length of rigid wheel base	13 ft. 9 in.
Total weight	521,200 lbs.
Weight on driving wheels	457,800 lbs.
Diameter of driving wheels	44 in.
Number of driving motors	12
Total capacity (continuous rating)	3200 h.p.
Total capacity (1 hour rating)	3500 h.p.
Tractive effort (continuous)	42,000 lbs.
Tractive effort (1 hr.)	48,500 lbs.
Tractive effort at starting 30% coef.	137,340 lbs.

The illustrations of the otheograph records that are here presented are those taken on the 5th, 6th and 7th, units from the receiving end of the apparatus.

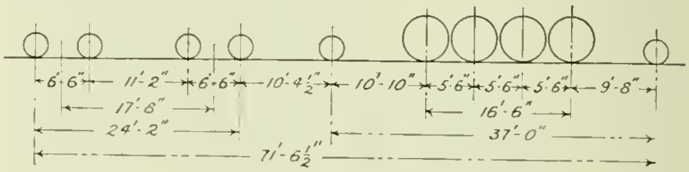
In comparing the records of the two locomotives it must be borne in mind that the weight on each driving wheel of the mikado locomotive was 31,000 lbs. while that on each driving wheel of the electric locomotive was only 19,075 lbs. In other words the weight on each driving wheel of the electric locomotive was about 60 per cent of that of the steam.

Now let us take the otheograms of the two at a speed of 10 miles per hour. Those of steam locomotive show the vertical stresses for each of the six wheels of the locomotive and the four of the tender; while those of the electric locomotive show each of the 14 wheels.

If we take the average vertical pressure as recorded on the three units for all of the driving wheels we find that that average for the electric locomotive is a little more than 58 per cent of that of the steam locomotive. This variation of 2 per cent from the static load ratios can well be accounted for by inaccuracy in measuring the diagrams; so that, taken as a whole, the effect of the counterbalance at a speed of 10 miles an hour is apparently inappreciable. But if we compare the records obtained on the individual units we obtain quite different ratios. For example, in the case of unit No. 5, the average load imposed by the electric locomotive was 70.3 per cent of that of the steam locomotive; on unit No. 6 it is 52.5 per cent and on unit No. 7 it is 51.7 per cent.

If we take the average on No. 5 as 100 and compare the other two with it separately for each locomotive; the steam locomotive developed 100 on No. 5; 120.3 on No. 6, and 107.8 on No. 7. The electric locomotive ratios were 100 for No. 5; 90.2 for No. 6 and 79.2 for No. 7; showing the variations that are indicated on the apparatus from unit to unit. In the case of the steam locomotive this might be explained by the varying effect of the counterbalance. But, in the case of the electric locomotive it is difficult to think of any other explanation than that of a variation in the distribution of the weight than that no one unit carries the full load of any single wheel, but is always influenced by the weight of the next approaching or departing wheel. That this is the case is shown by the failure of the indicating stylus to return to zero between the individual wheel impulses.

The length of the unit is 2 ft. and the wheel spacing of the driving wheels is 4 ft. 7 in. on the electric locomotive and 5 ft. 6 in. on the steam locomotive. So that were all load removed from each unit, when there was no wheel directly above it, the diagram should indicate no load. Whereas in the case of the electric locomotive the indicated load between the maxima, at 10 miles per hour, averages 94.4 per cent of the averages of those maxima; while those on the diagrams of the steam locomo-



Wheel Base of Mikado Locomotive

tive average but 61.5 per cent of the average of the maxima, showing that in both cases no unit is ever entirely free from a load while the locomotive is passing, and that the greater wheel spacing of the steam locomotive permits of a greater percentage of relief than does the close spacing of the electric locomotive.

It would appear from this that the otheograph diagrams give relative values rather than the actual amount of wheel load put upon the rail by any one wheel.

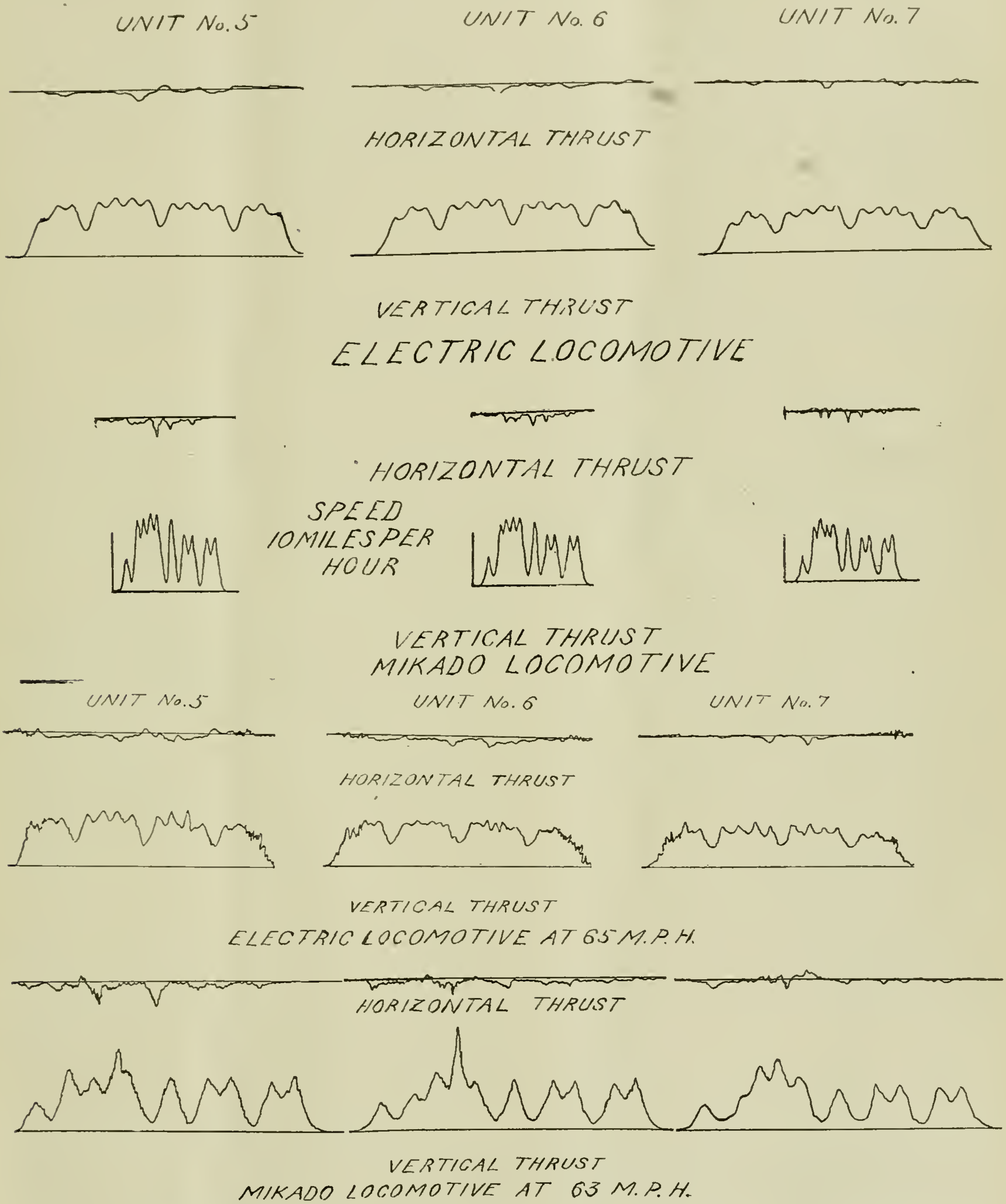
This discussion has, thus far, related solely to the slow speed movement of 10 miles per hour.

Both engines were run at high speeds and records obtained: the steam locomotive at 63 and the electric at 65 miles per hour.

Here we, at once see the effect of the counterbalance on the third or main driving wheel. At a speed of 10 miles per hour there is comparatively little difference between the wheels on any one unit and in one case (the 7th) the load apparently applied by the main driver was less than that applied by the one immediately ahead of it. But, at 65 miles per hour there is a wide variation between the main and the trailing wheels. On unit No. 6, the pressure indicated by the main driving wheel was 112.3 per cent greater than the average of the other three. It was also 26 per cent greater than the pressure imposed by the same wheel on unit No. 5, and 46 per cent greater than on No. 7. The evident explanation of this is that, when passing No. 6, the counterbalance was exerting its maximum downward effect. So as this occurred with the main driving wheel when on or near No. 6, the other wheels were nearer the other units when their counterbalances were in the approximate position occupied by that of the main driver on No. 6. But the indicated effects are paradoxical in the case of the leading driver whose maximum pressure was indicated on unit No. 5 and decreased to No. 7, where as the contrary would seem to have been the proper thing.

In the case of the electric locomotive there is remarkably little difference between the indicated imposed loads at 10 miles an hour and at 65. Indeed on taking the average of all wheels on all three units they are practically identical. But it is interesting to note, that despite the greatly increased impact of the main driving wheel of the steam locomotive the average impact of all four wheels is 23 per cent less at 65 miles per hour than at 10, while the average of the minima indications, was 13 per cent less at 65 miles an hour than at the slower speed or 10 miles per hour.

This drop in the steam locomotive average reduces the difference between it and the electric locomotive; the average of the latter being 73.9 per cent of that of the former.



As for the minima indications between wheel impact, the average of those of the electric locomotive at 63 miles per hour was 94.6 per cent of or practically the same as the average of those at 10 miles per hour.

These seeming inconsistencies can be readily explained on the same basis as that already offered to the effect that no unit is ever entirely free from load. In the case of the steam locomotive the greater wheel spacing permits a more marked reduction of load and an increase of drop between impacts than is possible with the shorter spacing of the electric locomotive.

There is also a probability of there being a lag in the action of the apparatus at high speed, just as there is a lag in the movement of thin ice when a skater passes rapidly over it. This would account for the lower average indications at high than at low speeds.

The horizontal thrusts as indicated by the upper lines of the diagrams are insignificant in amplitude and apparently the lateral thrusts do not belong to any one wheel, and an analysis would be very difficult. Occasionally there is a lateral thrust that corresponds with the leading wheel, but as often there is scarcely an indication of a thrust until the locomotive has moved for a considerable distance over the unit. This is especially true of the electric locomotive and checks with other observations previously made with another type of apparatus. In the case of the steam locomotive on the other hand there is nearly always a lateral indication corresponding to the leading wheel, but this does not mean that the lateral thrust exerted by the leading wheel is the greatest.

The indications, thus far obtained, though relative are of great value and opens up a vista of great usefulness in this class of investigation.

Fuel Association Holds Its Annual Convention

Address by R. H. Aishton, President of the A. R. A.—Report of the Committee on Locomotive Firing Practice

The sixteenth annual meeting of the International Railway Fuel Association was held at the Hotel Sherman, Chicago, May 26 to 29 inclusive. Features of the opening session were the addresses by R. H. Aishton, president of the American Railway Association, and Charles Donnelly, president of the Northern Pacific Railway. Mr. Aishton's address dealt with some aspects of the problem of fuel economy, while Mr. Donnelly's was devoted to the proposed consolidation of railroads to a limited number of systems as outlined in the Transportation Act. An abstract of Mr. Aishton's address follows:

Address of Mr. R. H. Aishton

Equally with everybody connected with the railroad service, and with the public who are dependent on its use, you gentlemen of the International Railway Fuel Association are also vitally interested in the future destinies of the railroads, their success and failure, and I know of no body of men who have any greater individual influence on their welfare than you and your associates on the battle line of the railways, who have to do with the fuel problem.

What is your problem? Considering the aggregate of the coal used on the class I railroads of this country the figures are so startling that we are apt to get lost, and the use of such figures suggests enormous and unlimited sources of supply. I am just going to quote you a few figures to paint the picture:

Total fuel consumption year 1923 (includes fuel oil equated)	146,500,000 tons
Made up as follows:	
Freight	90,000,000 tons
Passenger	32,000,000 tons
Switch	24,500,000 tons
Total	146,500,000 tons
Total cost	$507,000,000
Average cost fuel, per ton (all fuel)	3.46

Now that these millions are out of our system, we will try and get down to something we can understand. I never can just get adjusted to a comprehension of what a million means, because when I count over a thousand of anything I am utterly lost.

The Measure of the Problem

You are all familiar with the measure of freight service, commonly called a thousand gross ton miles. One of the large measures of efficiency and economy in moving a thousand tons a mile is how much coal is burned in that operation. Last year it took 160.2 pounds of coal turned into steam to move one ton of gross freight a thousand miles, or a thousand gross tons one mile, which, by the way, is 2.8 pounds less than 1922 and 1.8 pounds less than 1921.

I have here in my hand a pound of coal. It doesn't amount to much in looks, and few of us would stop to pick it up or refrain from kicking it down the bank, but yet in that one pound of coal as applied to one thousand ton miles lies the greatest opportunity for economy that I know of. I told you I wouldn't talk any more about millions, so I won't say how many millions or billions of ton miles were made in the course of a year. Suffice it to say that if you were to move a ton of gross freight one thousand miles, and did it with that pound of coal less than you used in 1923, and moved the same ton mileage as in 1923, you would have saved in the aggregate 561,-987 tons of coal, which at the prevailing price of coal, turned into money, would mean $1,944,999 less than in 1923. Is that worth going after? You men know better than I how you can do it.

In the same way, applying that same degree of saving, one pound of coal out of every 160.2 pounds used in passenger service, would have 200,000 tons of coal valued at $692,000. If you applied that same degree of saving to the fuel used in switch service and for other purposes, such as stationary boilers, stations and for heating purposes, etc., it would mean a further saving of 153,000 tons, or $529,000, making an imposing total of $3,165,-000 less cost than would have been incurred provided the same amount of fuel was consumed per 1,000 ton miles as in 1923.

We hear a great deal nowadays regarding scientific investigation, development of methods and appliances for bringing about wholesale greater economies in fuel, and while they may and no doubt do possess possibilities, in my opinion we must take cognizance of the fact that they all have one present vital disadvantage and that may be briefly expressed in the term "capital expenditures."

Capital expenditures depend on earning power of a railroad, and unless the necessary capital can be secured at reasonable terms, and this is, in turn, dependent upon the net revenue of the railways, it is absolutely futile to talk about large capital expenditures until condiions improve, although we all may know that such expenditures would produce a good return.

Furthermore do not overlook the fact that in the last two decades every known appliance for producing economy has been installed on new locomotives and to a very large extent on the larger locomotives as they go through the shop. While I will not undertake to say what the total capital expenditure has been, in the matter of superheaters alone it runs up over $125,000,000 and in 1923 alone, there was programmed and being installed superheaters to the value of practically $7,000,000 for this one item alone. In addition to that, large amount of capital have been put into brick arches, stokers, coal breaking appliances, self-closing fire box doors and all the appliances with which you are familiar that it is claimed add to economy, besides liberal installations of numerous experimental devices not yet proven but which may lead to economies in labor and fuel costs.

I think what we have got first and immediately to attack is the problem as it is, the tools as they are in our hands today and by the application of knowledge initiative, and a desire to bring about accomplishment get an immediate result, out of these vast capital expenditures. As I see, there is hardly an activity or an employee in any department of the railroads that does not have an opportunity to save on fuel consumption and to play its particular part in saving that pound of coal.

For example, the mechanical department. Is your design of a locomotive such as to bring about the most economical use of fuel? I don't know much about back pressure, but I do know something about an automobile. I know when I have carbon in the cylinder I burn more gas, create less power and bring about more dissatisfaction than is the case if I don't. Isn't back pressure something like the carbon in your cylinder? Are your exhaust ports, exhaust passages and exhaust nozzles properly designed? In other words, when your steam has done the work is the freest possible outlet given it to the atmosphere?

The cut-off and the speed also have something to do with back pressure. In Europe, I understand, they think this is so important that on a good many of the railroads they have a gauge in the engineer's cab that shows just what his back pressure is. It adds to the effective manipulation of the locomotive to get rid of the steam when used promptly and without delay, and if the necessary steps can be taken to save any of the back pressure incidentally it is reflected in reduction of fuel used.

I simply cite this to indicate the importance of this question of back pressure, not with the idea of even suggesting putting gauges on locomotives, but to indicate that investigation and care on the part of everybody in avoiding back pressure by well-known methods may bring about a very decided improvement.

Operating department: I just read a paper by Mr. W. L. Richards, an engineer of the Union Pacific road, on the advantages of pre-classification. This is its long name What it really means is switching orders or switching shipping tickets instead of cars, and holding cars when necessary to avoid extra switching, and in some cases movement to destination in train lots. This item alone will save you a pound of coal and more in switching service.

How about standby time at engine terminals? I have just read a statement in the March number of the *Engineers' Journal* that steam locomotives burn some 29,000,000 tons of fuel while they are out of action—standing by in yards or roundhouses waiting to be put to work. What about it? Whether the amount is overstated or not, is there not some opportunity for economy?

Improved locomotive terminals are more than mere mechanical contrivances offering means for reducing the cost of handling locomotives at the end of their run and conditioning them for the next run. They are operating features. Every hour that you can save for a locomotive at a terminal is that much to the good, not only in the actual saving of coal but in the use made of the locomotive investment. I will venture the assertion that in this one item alone you can pick up a part of that pound of coal I referred to.

I do not know of any subject that will be more productive ot useful information than a close check of means and methods, particularly the latter, to bring about a more intensive use of locomotive investment. This goes into everything, goes into the management of ash pits, shaking of grates, etc., and the desire on the part of everybody and every department to keep this locomotive moving, because when the locomotive is standing still it is not only the investment in the locomotive but a lot of other investments that are non-productive.

The yard, as I have always seen it, wants engines ready whether the trains are ready or not. The roundhouse always wants time. There is a direct conflict of interests that calls for co-operation. If I were to offer a suggestion it would be that the clerk of the yardmaster and the clerk of the roundhouse foreman get their heads together, put this pound of coal in front of them, and through co-operative action get the answer. You will save the pound of coal all right.

It is not all the engineer and fireman by a "long shot" in this problem of saving coal. I have a suspicion that a more general use of the "19 form of train order" would have a pretty direct effect on the coal pile. Anything that you can do to keep a freight train going, instead of stopping, means the saving of fuel.

One of the greatest means of bringing about a betterment is through the exchange of ideas, such as is brought about through a meeting of this character. If some fellow has an idea as to some better way of doing something, for his own good, for the good of the railroad he serves and particularly for the benefit of the entire railroad situation, he ought to make it known. If there is anything in it, you men ought to be big enough to recognize it and and go home to your managements and try to get it going. I know the temper of management well enough to know that anybody that has any proposition that will save a pound of coal, and particularly if connected with it they do not have some ideas about large capital expenditures being the only remedy to bring it about, they will meet with a very warm-hearted reception.

You have had in the past years papers without number from scientific bodies, from our great universities, from technical and practical experts, and the latest development was a series of most excellent papers brought out by a competition inaugurated by your association. In those papers practically every phase of this fuel subject has been covered.

It would be useless for me to stand up here this morning and tell you of the things that have been written, and which you have read on all these various matters. Just get out of your head that it is a big problem—it isn't; just get out of your head that it is wholly a scientific, technical problem, it isn't. All the science and technique in the world is powerless alone and without back of it the determination to do the job right. Just get out of your head that it is Bill Jones' problem—it isn't, it is your problem.

Just get into your head that in this pound of coal, and in your personal relation to it, lies the answer to the question. Having made up your mind that it can be done, do not at the end of this meeting, simply pass a set of resolutions and go and forget all about it; but remember there are two million other railroad employees in this country to whom it will be your job to get this message. Go home and tell your maangement about it, tell them you believe in it, if you do. Get them behind it, and I will predict that when you next have a convention of this association, you will find that you have made definite progress, and you will be able to point with pride to what you actually have accomplished.

Report of Committee on Firing Practice

The following is a report of the Committee on Firing Practice presented at the convention of the International Railway Fuel Association:

Experience is a great teacher. We must learn either from our own experiences or from experiences of others. But, how long does it require an inexperienced young man to fire a locomotive properly? A young man accepting the position of locomotive fireman is also serving his apprenticeship for a locomotive engineman. This experience usually requires one thousand days' work before being promoted to the responsibility of a locomotive engineman.

Every man employed as a fireman must be made to realize his personal responsibility to improve himself so he will be capable of passing the various examinations when called for promotion to position as engineman.

When starting this man out to learn to fire a locomotive he should be placed with some selected engine crew and before placed on the fireman's roster, he must be further instructed by the supervising officer. The instructions should be such as to make the fireman appreciate and know the value of fuel properly placed and the loss of fuel not properly placed in the firebox, including his own loss of labor. Active support must be given by supervisor, who will watch his progress to see that he does not acquire habits in his early stage of experience that will be wasteful in his work. An engineman's interest in saving fuel must necessarily cause him to do his part in seeing that the fireman keeps steam by intelligent use of fuel.

It is now the practice of some engine crews to run turbine generator and cab lights through the day at considerable fuel expense in order that they easily read the indications of gauges. Gauges and water glasses should be so constructed and located as to make it unnecessary to use cab lights during the day.

Many delays can be contributed to excessive grate shaking. The foundation of this delay usually occurs at the beginning of the trip when the fire is light. Many coals when thoroughly burnt require no grate shaking. Coals containing large ash contents must have grates shaken just enough to remove ash. It is very important to know that the ashes are not obstructing the air opening between mud ring and ash pan. Grates should never be shaken when engine is working hard. It is advisable to shake grates easily so as not to disturb the fire any more than necessary. Suitable shaker bars and shaker arm connections are very essential and a further study should be given to shaker bars and connections. The neglect of cleaning grates results in spoiled fires, increased consumption of fuel and in extreme cases delays or engine failures for want of adequate steam pressure. There is absolutely no excuse for not cleaning the grates properly before a new fire is built. The grates should receive regular and careful inspection at the end of each trip. Defective grates found should be promptly renewed, as defective grates with fingers burned or broken off will cause a considerable amount of fuel waste.

The importance of adequate air openings in to the ash pan has been brought out very clearly in this and other railway association meetings in the past. It is generally known among mechanical men in all branches, yet it is surprising to note that this is frequently overlooked and that new locomotives are still being built and older ones allowed to remain in service with marked deficiency in this respect. It is all the more surprising because it is generally known that air and oxygen are absolutely free and coal a costly commodity.

Air leaks into the front end will affect the steaming of the engine very materially. Sometimes when you ride on the front end, when the train is moving slowly, you would be surprised at the number of air leaks you will discover by listening to the inrush of air around the joints of the front end ring and front door and base of the smoke stack. A better method is to apply the blower in the roundhouse and look for these leaks with a lighted torch.

Cleaning of flues is another important item in the consumption of fuel. The maximum allowable time or mileage between flue cleanings, consistent with real efficiency, should be determined in the various districts and for the several classes of power and service, and thereafter flues should be cleaned within the limits thus determined. When correct apparatus and method for flue cleaning are established, they should be maintained, records kept and efficiency checks made by supervising officers to insure good work on the part of the flue cleaners. Advantages to be gained by the superheating apparatus are frequently lost by low temperature in steam due to plugged flues.

Steam leaks in the superheater elements are frequently found. It is a cause for considerable waste of fuel and hard steaming engines if such leaks are not found and repaired promptly. It is recommended that regular tests be made, perhaps quarterly tests will prove sufficient, to discover such leaks. The nozzle should not be bushed to overcome such defects. To do so is costly on the coal pile.

It is very important that the superheater damper is maintained in proper alignment. If the damper has not sufficient opening or fails to open, it will effect the superheater temperature and the fuel and water consumption will increase rapidly in corresponding degree with the dislocation of the damper. The damper is a very important appliance of the superheater engine and it is not given the attention generally that it should have.

Results of covering smoke stacks when fire was dumped indicate that there is a big saving both in time and fuel in firing up a locomotive where stack covers are used. This saving does not call for any extra labor or great effort. In placing a cover on the stack the saving commences and continues until cover is removed. When comparative tests have been made it has shown that when smoke stack covers have been used, boilers hold the steam from five to eight hours longer than when stacks are uncovered.

An important subject that should be followed up is the fire building in locomotives in advance of leaving time. When a locomotive is fired up a long time in advance of leaving time, front end netting becomes stopped up, the fire becomes dirty which often results in engine not steaming and failing on line of road. To provide a safe margin, two or probably three hours before leaving time is considered ample to start a fire in locomotive intended for any service.

Oil Burning Locomotives

The firing of an oil-burning locomotive differs very materially from the firing of a coal-burning locomotive, and more careful attention is necessary in oil-burning than in an oil burner demands that close attention be given at all times in order to produce satisfactory results. In fact, a good fireman on an oil-burning locomotive must be watchful and diligent, for he can save or waste more than he could on a coal-burner.

The conditions are such that no arbitrary instructions can be given as to how much steam should be used for the atomizer, how much the dampers should be opened, or the exact temperature to which the oil in the tender should be heated. These details must be left to the intelligence of the engine crew, and their experience should indicate the adjustments necessary under various conditions.

It should be remembered that the preservation of the firebox and flues is as important as keeping up steam or making time, and rapid changes of temperature in boilers cause expansion and contraction that will result in leaks developing. To this end, engineers and firemen could co-operate to prevent cold air from being drawn into the fire-box and through the flues.

The fireman should be at the firing valve when the engine is started. He should increase his fire immediately before the throttle is opened and should reduce it immediately after the throttle is closed. Any change in the position of the throttle or reverse lever while running should be correspondingly anticipated by the fireman and the fire regulated accordingly. The fire must at all times be regulated to suit the work the engine is performing. When there is a probability of the driving wheels slipping, the firing valve should be opened sufficiently to guard against the fire being drawn out by the exhaust in case slipping occurs. At other times the fire should be regulated so as to maintain uniform steam pressure most economically.

The engineer should call the fireman's attention when about to change the position of the throttle or reverse lever.

A white incandescent color at the peep hole in the fire door and the complete absence of smoke at the stack, without an objectionable amount of air in the gases of combustion, is most desirable. Black smoke indicates incomplete combustion, waste of fuel and should be avoided. Leaky steam pipes, superheaters, flues, fire-box seams, or improper combustion from any cause will produce a ruddy color in the fire-box.

The firing valve and not the injector should be used to control the steam pressure. The operation of the injector should be as nearly continuous as possible while the engine is working. Variations in the water requirements of the boiler should be met by partially opening or closing the injector water valve as required. If, when the engine is working, the steam pressure approaches the popping point and the injector is shut off, the injector should be started, only if the boiler needs water. If no water is needed the fire should be reduced. If the injector is started, the firing valve should be left alone or opened slightly if necessary to maintain working pressure. In no case should the fire be reduced and the injector started at the same time in order to prevent popping.

The use of the injector when standing or drifting should be avoided as far as possible. When it is necessary to use the injector under these conditions, it should be used intermittently and a good fire should be maintained as long as the injector is in use.

Forcing the fire on an oil burning locomotive is likely to injure the fire-box sheets and flues and in the event of it being absolutely necessary to force the fire beyond a reasonable point, unusual care should be taken to see that sufficient water is on the crown sheet to prevent damage.

When standing or drifting, the dampers should be closed and a light fire maintained in order to maintain as nearly as possible a uniform temperature in the fire-box to prevent injury to the fire-box and flues.

Mechanical Locomotive Stokers

It must be distinctly understood that the mechanical locomotive stoker is in no sense of the word automatic, but that it is a mechanical device designed to assist in obtaining the utmost efficiency from every pound of coal fired. The object in applying the stoker is to do something with the locomotive that is impossible with the scoop shovel and man power. The operation of this device requires intelligent handling which can only be furnished by the firemen depending on his ability, skill and good judgment coupled with the co-operation of the engineman in handling the locomotive, or he waste it through lack of knowledge or inattention to his duties. It follows that the fireman must have sufficient knowledge of its principles of operation to begin with. Therefore, as the stoker is not automatic, it is necessary that the fireman furnish the knowledge incidental to firing the locomotive regardless of whether the coal is put in the fire-box with a scoop or with a stoker.

The stoker will crush the coal, convey it from the tender to the fire-box and distribute it over the grate surface, provided the distributing mechanism is properly manipulated. However, as the stoker cannot see where it is putting the coal, or cannot see how the draft is distributed over the grate area, which of course governs the manner in which the coal is burned, it follows that it is the fireman's duty to look at the fire occasionally. If he sees that he did not set the distributing mechanism right, the first thing is to make the necessary adjustment. Firemen are inclined to wait until the steam pressure begins to drop back, and then if they cannot bring her back to the popping point by increasing the speed of the stoker, they will examine the fire in order to see why the locomotive is not steaming the same as it did starting out. In a case of this kind they usually find that banks have formed in some part of the fire-box, sometimes so heavy that no draft can get through them, consequently reducing the effective coal burning grate area in proportion to the size of the bank. Of course, when a condition of that kind is noticed, firemen usually get busy with the clinker hook to pull the bank down, or else with a shaker bar try to reduce the size of the bank by shaking the excess into the ash pan. Either of these methods simply makes extra work for the fireman that could have been avoided, and usually results in excessive coal consumption. Therefore, it follows that if the fireman wants to actually save himself work, and also wants to keep the coal consumption within reasonable limits, he should look in the fire-box quite frequently, examine the condition of the fire, and if the distribution is not as it should be, change it until he gets it right.

The whole trouble is, the stoker is not human, consequently it cannot tell whether the coal coming forward from the tender consists of practically all crushed lumps or of the finer particles such as slack or screenings. Regardless of the method of distribution used, it takes more power to scatter the lumps than it does the finer coal. First, because the lump is heavier; and second, because the draft has a material effect on the finer coal, tending to pull it forward. Therefore, even though the distribution was perfect when starting out, should the character of the coal in the tender change as it is liable to do when using mine run, i.e., change from lump to screenings or vice versa, it follows that the distribution will be changed correspondingly; as for instance, if, as is usually the case on the beginning of the trip, the large lumps are down against the coal gate so that the first coal the stoker gets is lump, the distributors are adjusted to handle the lump and scatter it over the grate area, and then the lumps quit coming and the slack commences to feed into the conveyor through, if the distributor pressure is not reduced the excess pressure, aided by the draft, will have a tendency to carry the greater part of the screenings under the arch and the next thing is a bank, and usualy closely on the heels of a bank with some kinds of coal, we find clinkers, and following banks and clinkers, we will find trouble. Therefore, as previously stated, the fire should be watched just as carefully when stoker firing as when hand firing, and the pressure on the distributors where steam jets are used or the speed of the distributors where mechanical means are used, should be changed with the character of the fuel.

When banks are formed in a fire-box being fired with a mechanical stoker, it is preferable, if possible to use the same method as would be used under similar conditions if the locomotive is being hand fired; that is, try to fire around the bank and burn the bank out. The reason for this is that some coal if a bank is pulled down with a clinker hook, it always results in the formation of a clinker, and as we all know, clingers, if large enough, mean a loss in steam pressure and considerable trouble for the fireman in his efforts to remove it. It it is not possible to change the distributors so as to fire around the bank, the next best thing is to shake that section of the grates on which the bank has been formed so as to start a little air up through it. Then reduce the amount of coal being fed by the stoker and help out a little with the scoop until the bank has been burned down.

As a rule, beginners with mechanical stokers fire too heavily. It is for this reason that all instruction books lay particular stress on starving the fire. It is really surprising how much a stoker fire can be starved and still maintain steam pressure. The old idea that stoker firing is uneconomical firing has long ago been exploded, as numerous tests conducted all over the country with every kind of stoker and under all conditions, have demonstrated that an expert with a stoker can get more steam out of a pound of coal than can be obtained hand firing. This is due to the fact that there is not that same cooling effect as occurs in hand firing when the door is opened to introduce coal. In order to get full economy, however, it is necessary that the fire be kept light or thin, as very careful tests conducted by the Bureau of Mines have demonstrated that where a fire is six inches or more in thickness it is impossible to get enough air through the fire to consume all the volatiles being distilled from the coal.

In a stoker fired locomotive a much thinner fire can be carried than in a locomotive hand fired and operated under same conditions. This is due to the fact that the stoker has a reserve capacity sufficient to meet any increased demand; that is, if you are carrying a nice thin fire and getting ready to go up against a hill, the speed of the stoker can momentarily be increased so that a sufficient amount of coal is carried into the fire-box to meet any demand. A good fireman will anticipate the movement of the reverse lever and the throttle and act accordingly. If the fire was equally as thin on hand fired locomotives, it would be physically impossible for a fireman to shovel in the coal as fast as required under such conditions. Therefore, in a hand-fired locomotive the fireman must have a little reserve to draw from, which means a little thicker fire. This is a point that must not be overlooked on a stoker fired locomotive, for this reason; should the stoker stop through any cause, with a fire as thin as it should be, and the engineer continued to work the locomotive to its maximum, the fire would all burn out within a very short distance, and consequently, might result in quite a delay getting it built up again. If the trouble cannot be immediately located and corrected, the fireman should begin bailing in coal by hand as fast as possible, and the engineer should shut off if conditions warrant it, but if not, should at least ease off until the fireman has shoveled enough coal into the fire-box to meet such demands as might be made on the boiler for steam, while he is hunting and correcting the trouble with the stoker.

The stoker will do all the work required of it, but it must have the co-operation of the engine crew.

It is really not a hard job; to the interested fireman it is quite a source of satisfaction to be able to show a nice light level fire on arrival at the terminal, indicating that he was watchful on the trip, and also indicating that he was firing economically. Everybody likes to be patted on the back occasionally for a job well done. Therefore, is there not more satisfaction obtained should the Fuel Supervisor, or the Master Mechanic, or the Round House Foreman, or the Hostler, or even the Fire Knocker, get up on the engine and when he looks into the fire-box say: "That boy is sure an artist with a stoker," instead of having one of them when he looks at the fire, remark: "Either this fellow doesn't care or he doesn't know how to fire a locomotive."

Some firemen make a practice of firing with a mechanical stoker about the same as they would be hand, i.e., if they were firing by hand they would throw in a slung of fifteen or twenty scoopfuls, then get up on the seat box and wait until it burned out before throwing in another slug. They handle the stoker the same way, viz., speed up for a few minutes so as to throw a big slug into the fire-box; then shut it off and wait until it is burned out. We all know that the first method of hand firing is not economical; neither is the slugging method economical with a stoker, although there is not the same loss obtained as in hand firing owing to the fact that when the slug is being put in by hand it is necessary to keep the fire door open, thereby allowing an inrush of cold air which materially reduces the temperature of the fire-box being too low to ignite and burn these gases. This also reduces the blanketing of the fire and the escape of the unburned volatiles, usually in the form of a dense cloud of black smoke caused by the temperature of the fire-box being too low to ignite and burn these gases. This also reduces the superheat temperature in the steam reaching to the valve chamber, also fills the flues with soot which is a very strong non-conductor of heat.

The proper method of firing with a stoker is a pretty close approach to the one-scoop method advocated some years ago, the only difference being that with the one-scoop hand firing method a small quantity of coal is distributed at frequent intervals. With the stoker, if properly manipulated, small quantities of coal are being introduced continuously so that the total amount of coal fed to the fire-box however, in say one hour, is practically the same as though fed by hand with the single scoop method. By just keeping the smallest possible quantity of coal necessary to maintain steam pressure going in all the time, the fire is kept at an intense white heat so that the greater part of the finer particles of coal and coal dust are burned in suspension, and the intense heat created will burn practically all the volatiles being distilled from the heavier particles of coal which are being burned on the grates. Consequently, instead of the intermittent clouds of black smoke pouring from the stack, there will be but a faint gray haze.

When a locomotive is being stoker-fired it is not always possible with any type of stoker to say just how much coal is being fed into the fire-box therefore it is necessary to watch the stack and watch the steam gauge. If the stack begins to clear up so that the faint gray haze is not visible, the fireman should first see if the stoker is running, and then if it is getting cold. Sometimes, especially in cases where the coal consists mostly of large lumps, these will have a tendency to arch over the openings in the conveyor trough, thereby stopping the further flow of coal into the fire-box. At other times, when using slack or screenings, especially if it is a little wet, the screenings will not slide forward into the trough. In both of these cases the remedy is, of course, obvious.

The Pennsylvania 2-8-2 Type Electric Locomotive

By W. H. EUNSON

Railway Equipment Engineer, Westinghouse Electric & Mfg. Co.

In 1923 the Pennsylvania Railroad completed designs for new single-phase electric locomotives for use in either freight or passenger service on 11,000 volts, 25 cycles, alternating current. These same designs also covered a modification of the control equipment to permit the operation of these locomotives in passenger service on 650 volts direct current. The mechanical parts were designed and built by the Pennsylvania Railroad, the electrical parts by the Westinghouse Electric & Manufacturing Company and the locomotives were assembled at the Juniata shop of the railroad company.

The first locomotive, known as the L-5, was placed in freight pusher service in February of this year, on the 11,000-volt alternating current section between Overbrook and Paoli, Pa. A second, equipped for passenger service at 650 volts direct current, and known as the L-5-A has just been completed.

The principal dimensions and weights of these locomotives being as follows:

	A-C. Locomotives
Length, between pulling faces of coupler knuckles	68 ft. 2½ in.
Total wheel base	54 ft. 11 in.
Rigid wheel base	22 ft. 3 in.
Height over pantagraph in locked down position	15 ft. 6 in.
Width overall	10 ft. 1 in.
Length of cab	26 ft. 0 in.
Length of hood	16 ft. 9¾ in.
Diameter of driving wheels	80 in.
Diameter of guiding wheels	33 in.
Weight, total	408,600 lb.
Weight on drivers	308,600 lb.
Weight on guiding wheels	100,000 lb.

The locomotives are of the side rod type. Each locomotive is equipped with four Westinghouse type 418 single-phase commutator motors. Two of these motors are geared to a jackshaft, which is connected to two pairs of drivers through the side rods. The two center drivers are flangeless.

The frame is composed of four main steel castings accurately machined and substantially bolted together to form a continuous framework extending the full length of the locomotive. Each end of this frame is formed into a cradle containing the jackshaft and motors, suitable bearing seats for both motors and jackshaft being provided in the frame.

Pennsylvania Railroad's Class L-5 Electric Locomotive—Built at Altoona Shops of the Railroad Company

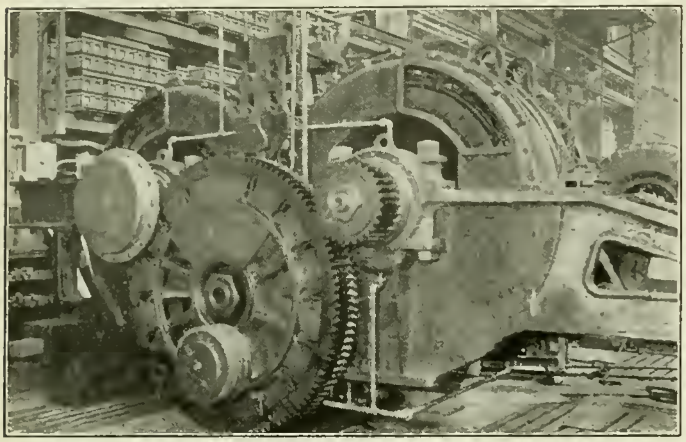
Lubrication of motor and jackshaft bearings is obtained by an oil circulation system. Under each jackshaft, cast integrally in the main frame, is an oil reservoir holding an adequate supply of oil. Geared to the jackshaft is a plunger type pump which, when the locomotive is running, pumps the oil from the reservoir to a distributing manifold. From this point, the oil flows under low pressure to each motor and jackshaft bearing and from thence back to the reservoir. An indicator, consisting of a sight feed valve is located in each operating cab.

The part of the frame extending over the driving axles is carried up to form a support for the equipment deck, the heavier pieces of equipment being bolted directly to the frame. This relieves the cab structure of equipment weight and permits the cab to be placed in position after the heavy equipment work is done.

The guiding trucks on each end of the locomotive are of the radial center-bearing type equalized with the main drivers through bell cranks and tension rods. Flexibility is obtained between the truck and bearing plate by means of flat leaf springs placed transversely and resting in the swing links supporting the weight on the truck.

Each jackshaft is equipped with two sets of flexible gears, one set on each end of the shaft. A set of gears consists of a cost steel gear center carrying the side rod pin, two heat-treated gear rims and a number of flat spring flexible units interposed between the gear rims and the center.

The motors each carry two pinions meshing with the gears, the pinions on the motors nearest the center of the locomotive being solid and those on the outer motors being flexible. The flexible pinions are similar in construction to the gears, using duplicate flexible elements. This arrangement eliminates high local stresses between pinions and gear rims due to light irregularities from machining or heat treatment.



Motors of Electric Locomotive Assembled in Cradle for Testing

The main transformer is oil insulated and cooled by circulating the oil through a radiator arranged for forced ventilation. The transformer tank is made from 3/8 in. and 1/2 in. boiler plate flanged and hydraulically riveted. It is bolted directly to the locomotive frame so that the weight of the transformer and tank is not carried by either the equipment deck or cab structure. Special transformer oil having a low congealing temperature is used.

The switches for transferring the motors between transformer taps are of the electro-pneumatic type having a continuous capacity of 1500 amperes. Main and arcing contacts are of the butt type and are easily replaceable. The arcing contacts and blowout coils are shunted out of circuit when the main contacts are closed. There are twenty-one of these switches on each locomotive.

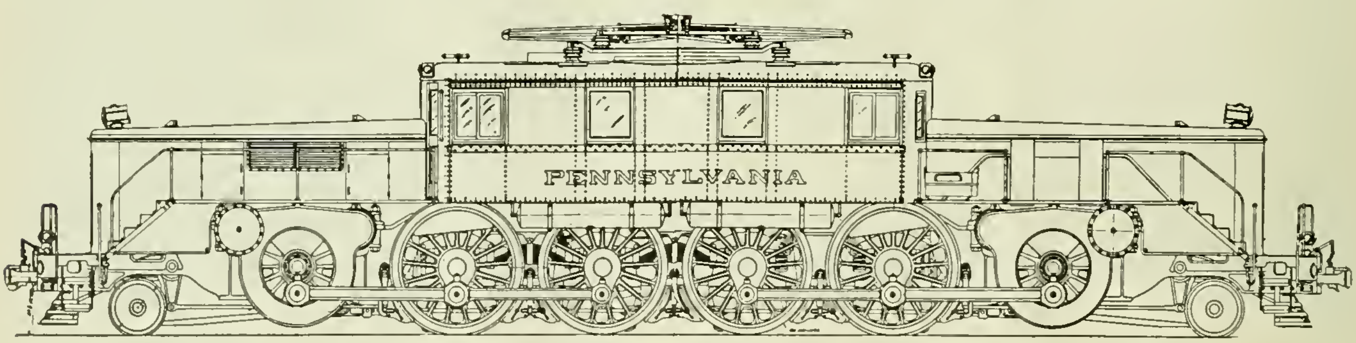
A reverser is supplied for each pair of motors and is located in the extreme end of the locomotive under the hood, and as near the motors as practical. The contacts are of the laminated brush type. The operation of the reversers is controlled electro-pneumatically.

The air brake equipment is the type 14 E. L. an adaptation of the No. 6 E. T. to electric locomotives. Compressed air is furnished by a single compressor having a capacity of 150 cubic feet of free air per minute when operating against a pressure of 140 lb. per square inch. The compressor is driven by a Westinghouse series A-C. motor type CC-72-C.

Energy for control and lights is obtained from a storage battery with a normal voltage of 30. The battery is charged from a small M. G. set consisting of an A-C. single phase motor and D-C. generator.

Control of the operation of the locomotive is obtained through a master controller located in each operating compartment.

The changes necessary in the locomotive to make them suitable for either freight or passenger service are entirely in the gearing, the gear ratio for the freight locomotive being 118:30 and the passenger locomotives 98:50. Small hydraulic tools have been designed suitable for either removing or pressing on both pinions and gears, so that this operation can be carried out in any shop where facilities for handling these locomotives will be available.



Side Elevation of Pennsylvania Railroad Electric Locomotive Class L-5-A

The A-C Locomotive

The traction motors are of the interpole type and the excitation of the interpole fields is obtained by suitable resistance shunted across the interpole winding. Forced ventilation is furnished by a fan which draws air through the windings and blows it through and around the interpole resistance grids. A fan is furnished for each motor. The fans are driven by a small A.C. series motor known as the Westinghouse type XB-52.

The brushholders of the type 418 motors, together with the interconnections, are mounted on a separate rocker ring which can be completely turned around when inspecting brushholders or replacing brushes.

The testing of these motors was carried out by mounting each pair in a locomotive frame section forming a motor cradle with the jackshaft, gears and lubricating pump in position. One of the illustrations shows the motors mounted in position for testing.

The D-C Locomotives

The D-C. locomotives are designed to use the same main and auxiliary motors as are used with the A-C. locomotives.

The changes in equipment involve the omission of the main transformer, preventive coils, unit switches, pantagraph, master controllers and some details from the A-C. equipment and the application of accelerating grid resistors, 3,000-ampere 650-volt electro-pneumatic switches, third rail shoes, duplicate master controllers to those on locomotives now operating in the New York Terminal and Tunnel zone, and some small lighting and protective details.

The 3,000-ampere, 650-volt electro-pneumatic unit switches are of the laminated brush contact type of which there are twenty-three in each locomotive.

The ratings of the L-5 locomotive geared for both passenger and freight service are as follows:

The L-5 Geared for A-C Freight Service

	Amp. per Motor	B.H.P.	T.E.(lb.)	M.P.H.
Max. T. E....	4250	3450	100,000	12.5
One Hour ..	2600	3300	59,000	21
Cont.	2300	3070	50,000	23

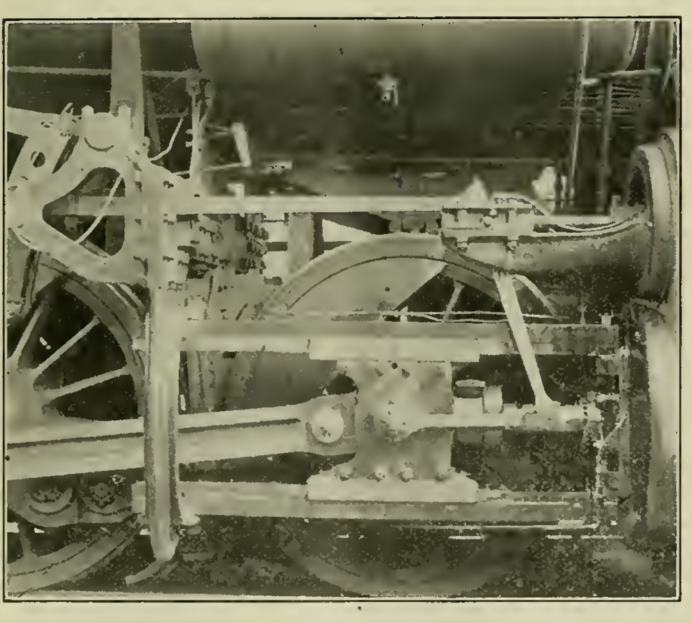
The L-5 Geared for A-C. Passenger Service

Max. T. E...	4250	3450	54,000	22
One Hour ...	2600	3300	29,500	42
Cont.	2300	3070	25,000	46

A Novel Method of Locomotive Lubrication

The Woodward Iron Company of Woodward, Alabama, has made an application of a novel method of lubrication to one of their Santa Fe type locomotives. It consists of a force feed lubricating pump of the Forcit type delivering oil, under pressure to the several bearings of the locomotive. Three pumps are used, two having a capacity of 5 gallons each with 22 feed pipes each and the third having a capacity of 3 gallons with 12 feed lines leading from it. All of them being provided with check valves.

The Alemite system of lubrication is used at the front and back ends of the eccentric rods, bottom and top of the lifting hanger, the bushings of the link trunnions, lifting shaft boxes, the front and back ends of the union link, the front end of the radius rod, the top of the combination lever and on all of the knuckle pins and bushings. Nearly all of the other bearings on the engine were fitted up to use an Alemite grease gun. The cylinders and valves were lubricated with the ordinary hydrostatic lubricator.



Force Feed Lubrication Pipes for Valve Gear and Upper and Lower Guides on Locomotive of Woodward Iron Company

The pumps are driven from the valve gear on the right hand side by a connecting rod that extends to a crank arm beneath the smokebox. The crank arm is of sufficient length to drive both pumps at the front end.

The oil is conveyed to the several points of delivery by flexible piping, which is held in place by clamps.

This method of force feed lubrication was applied to the following list of points on the two sides of the engine.

Back driving box hub, main shoe and wedges, back intermediate shoe and wedges, front intermediate driving box hub, front shoe and wedge, front driving box hub, engine truck box, engine truck box hub, trailer truck box, trailer truck box hub, back shoe and wedge, from intermediate shoe and wedge, back intermediate driving box hub, main driving box hub, link block, valve stem piston rod, back top guide, front top guide, bottom guide, outside valve stem guide, inside valve stem guide.

The illustration shows the method of applying the feed pipes to the valve gear and the upper and lower guides.

For the lubrication of the driving boxes, three lines of flexible pipe are led from the lubricator and welded to three points on the equalizer over the driving box. The central pipe is welded over the center of the box and is provided with an outlet leading to the waste pocket. The other two are at the sides and serve to lubricate the shoe and wedge.

The reservoirs of the pumps have a sufficient capacity to carry a supply for 10 days the engine being worked on a 12-hour mine run.

There is not much if any saving in the amount of oil used, as the amount required is about the same as when the engineer did the oiling in the usual manner, but there is a decided advantage in that the oil is applied regularly and automatically to all of the bearing surfaces.

The system has now been in use for about six months and the indications are that it will result in increasing the life of the bearing surfaces to which it has been applied.

Compressed Air Locomotives in Mines

The use of compressed air driven locomotives in mines is quite common in Germany. In the Dortmund district alone there were no less than 624 locomotives of the type used in 1920 and they hauled about 15,000,000 tons of coal during that year.

The compressed air in the storage mains is maintained at a pressure of about 3,000 pounds per square inch. The storage charge for the locomotive, which starts at approximately this pressure, is carried in long weldless steel cylinders, three or four in number and twelve to eighteen inches in diameter. They are practically as long as the locomotive and leave a seat for the driver in the rear. The necks of the bottles or receivers are held in place by a vertical plate, while the other or forward ends are held by a stout strap attached to the frame below. In operation, the air flows from the storage through a pressure reducer to a receiver, where a constant pressure of about 200 pounds is maintained.

The air, after leaving the first or high-pressure cylinder where it is used expansively, passes through a series of tubes in which its temperature is raised or restored to that of the mine air, and then it does its final work in the low-pressure cylinder. The distribution of the air is controlled within wide limits by balanced-piston valves and a link motion just as in a steam locomotive. With one charge of air the engine can travel with its load about six miles. The locomotives serve either as mainroad or gathering locomotives, and weigh from 3½ to 7 tons. Their power is from 10 to 30 h.p. Still larger locomotives are used for tunnel work and in plants exposed to the danger of fire.

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The Atlantic City Conventions

It may be that the June conventions, as they were popularly called for many years, are not worth while, but either from force of habit or from desire, supply men and members show a greater enthusiasm than when there is simply a quiet gathering for the discussion of a few technical papers and the transaction of the necessary routine business of the association or associations as they were.

Already weeks ago all available space for exhibits had been engaged, and rumor tells us that the display of this year will exceed in elaborateness anything that has ever gone before. Of course such an exhibit does not pay, if we consider as "paying" the securing of orders on the ground. But a fine exhibit is apt to make an impression that is lasting, so that long after the cost of the display has been written off the books, a substantial order may come wandering in as a direct result of the show at Atlantic City. At any rate, pay or no pay, the exhibit presents all of the appearance of popularity. Of course such a gathering and display as this would be impossible were it not centered about the nucleus of the convention itself.

It is a tolerably safe statement to make, that no other technical association in the world is the sponsor for such an assemblage of valuable literature of an intensely practical nature as are the two great railroad associations of the Master Mechanics and the Master Car Builders. There is almost nothing that is exclusively scientific or theoretical, but all through the long series of proceedings, extending back now, for well over half a century, the practical application stands forth as the predominating feature in every case. And this practical application is so presented that he who runs may read. The result of which has been of untold benefit to the railroads.

This year's program promises to be no less valuable than the many that have gone before.

The second day's proceedings promise to be ripe in locomotive lore, the only fear that can be expressed in advance is that the richness of the feast may be too great for the digestive capacity of the assembly. "The Modern Locomotive" presented by Mr. Winterrowd who has had a long experience as mechanical engineer of the Canadian Pacific Railway; "The Three-Cylinder Locomotive" by Mr. Blunt of the American Locomotive Company who is an enthusiastic believer in the design, and looks upon it as the coming type of locomotive; and the "Relation of Track Stresses to Locomotive Design" by Mr. Ripley of the Atchison, Topeka and Santa Fe, which should afford a field of endless discussion; make up a program for a single morning's work, that makes one doubt the possibility of doing justice to any one of the three. But whether the discussion is unduly curtailed or not, the final contribution to technical literature that will be made will be of very great value.

It has been the customary practice for many years to have an address from someone associated with the Interstate Commerce Commission, and the address of this year by Mr. Frank McManamy will be looked forward to and welcomed with the interest that it will deserve.

The transition from the man who had merely to do and deal with things mechanical to the officer whose time is chiefly occupied with administrative duties, is marked by the appearance of two addresses by railroad presidents who come to speak of administrative matters and whose presence would have seemed strangely out of place in the old days of the parent associations when their members had not dreamed of executive authority.

The sessions will close with the presentation and discussion of the three important subjects of welding, brakes and wheels, that cannot yield in value to anything that have proceeded them. So that whether the holding of these conventions is a proper thing or not when viewed from a purely economic aspect, the prospect is that the gathering of this year will be marked by a mechanical display that it would be a direct loss to any railroad man to miss and a valuable addition to the technical literature of the world.

Development of the Three Cylinder Locomotive

In our issue for April was published the results of tests of the three-cylinder locomotive on the Lehigh Valley Railroad together with comment on different features with particular reference to economies in operation.

A comparison of earlier or first design of any developed or successful device with the latest models seems to emphasize the weak points in the original and this is well brought out in a review of designs of locomotives.

In the late nineties, in making a study of foreign designs, both French and British, we were rather favorably disposed to the De Ghlen type of four-cylinder compound although we recognized the crank axle as a weakness that would be more pronounced in American locomotive practice, still we ventured to bring out an engine of this type with a modified cylinder arrangement.

Webb Three-Cylinder Like a Balky Horse

In making a study of British designs at the time referred to, we were astonished to observe the things, or the one essential thing that the Webb three-cylinder compound locomotive *would not do* and that was to pick up its train and leave a station when the engineer was ready and attempted to leave. In fact, after watching an engineer spend from three to seven minutes vainly trying to get away from a station with one of these engines, during which period the engine or drivers would go both ways at once and still not move the train scarcely an inch, we naturally compared them to a contrary balky horse, practically useless as a reliable medium of transportation. We held our peace on this fatal defect, a recital of the true facts might cause some to question our veracity. Recently, however, corroborative evidence of a high order was made available.

At a recent meeting of The Western Railway Club in Chicago, Mr. George C. Jones of the American Locomotive Company presented a very interesting paper on the Three-Cylinder Locomotive bringing out many new and interesting features. Following its presentation, the discussion was opened by Mr. H. T. Bentley, Gen. Supt. Motive Power & Machinery of the Chicago & North Western Railway who in the course of his remarks explained why the Webb three-cylinder compounds were a failure. About 200 of these engines were put in service on the London & North Western Railway of England. We quote the following from Mr. Bentley's remarks:

"As Mr. Jones says, it is evident there was something radically wrong with the first three cylinder compound locomotives used on the London & North Western Railway of England or they would not have been taken out of service. That is absolutely correct. I think you all know that I am a very truthful man, and therefore when I tell you those engines would go two ways at the same time you willl believe it.

"By a peculiar arrangement of the valve gear on the inside, the low pressure valve motion, when an engine had backed up there was a stop pin in connection with a slotted eccentric, and after the engine had backed up it would continue backing up very satisfactorily and go the right way, but when you started to go ahead again with the two high pressure cylinders, the low pressure valve gear would not come into play until the engine had made a quarter of a revolution and started the inside valve gear going, and I can tell you that I have seen those engines five minutes trying to get out of a station with one pair of wheels, going one way and the other going the other, due to no side rods being used which permitted the wheels to revolve in opposite directions.

"Those engines had a Joy valve gear which Mr. Jones mentioned.

"I have been working with crank axles for a good many years. I would not like to say how many; and while they may be all right now, they were very far from being all right when I had to work with them. It was nothing unusual to see a crank axle break, and as most of our engines had two inside cranks, you can imagine that it was rather crowded."

We believe that the next few years we will witness much improvement in our present standard locomotive and its accessories, and while a crank axle on a locomotive is not desirable as compared with the plain type, yet a single crank is less objectionable than a double crank. If the former can be made dependable and does not make for too high maintenance costs, it would appear that this type of engine bids fair to contribute much to operating economies.

The Austrian State Railways

In a recent issue of the *Saturday Evening Post*, Isaac F. Marcosson tells a story of the conditions existing on the Austrian railways as a result of years of state management or mismanagement due to the deficit and the large number of employes carried on the payrolls. Before the World War the Austro-Hungarian railway system had a mileage of between 11,000 and 12,000. After the division of the monarchy into autonomous states Austria was left with only 3,500 miles of track, but maintained a personnel of nearly 100,000 workers on the payroll. In other words, she had a staff for the reduced mileage equal to that of the original imperial system. Two-thirds of the chronic deficit since the war was due to wasteful railway expenditure.

Since waste is always a diverting subject, let me point out one or two instances in the Austrian railways. There were six switch greasers for every switch in the smallest of what we would call tank towns. A typical story will show the old attitude of the Austrian railway worker. At a certain cross-roads was the usual safety gate to be lowered when trains pass. Two trains made this particular crossing each day, one at eight o'clock in the morning and the other at nine o'clock at night. Despite the fact that he was given a house free of charge and could loaf all day and night except for the period of the passing of the two trains, the day gateman refused to work after eight o'clock in the evening because it meant a violation of his eight-hour-day principle. The result was that a second gateman had to be employed for the sole purpose of lowering the gate for the solitary night train.

When the Austrian railroad controllers screwed up their courage to the point of discharging a man they gave him a pension which amounted to nearly 90 per cent of his wages. They not only lost his services but were subject to practically the same cost as when he worked, or went through the motions of working. They were out both ways.

This kind of procedure not only drained the public funds but begot an atmosphere of indolence that was thoroughly destructive to reform and progress. The moment Chancellor Seipel started his housecleaning the ax fell on the railway service. By July first last nearly 40,000 employes had been dismissed and many more were booked for discharge.

Railroad rates have been advanced five-fold and the pernicious practice of giving every public official a free pass or a reduced rate has been abolished. In 1921 I wondered why the Austrian trains were so crowded. Upon inquiry I discovered that four out of every five passengers either had passes or had rates that made traveling cheaper than living at home.

One of the most encouraging developments in the steam-transport situation in Austria was the passage last summer of an act by parliament which puts the whole railroad administration on a new basis. Although the railroads are government owned and will continue so, they now pass from the control of a cumbersome ministry to what amounts, for all practical purposes, to private management. An expert general manager is in control with his own board of directors. Following this marked innovation, the railroads will cease to be a direct state enterprise and become a separate enterprise responsible for its own organization and management. This is another definite step forward.

As it is throughout all of central Europe, coal, its scarcity and high cost, constitutes one of the great economic problems of the country. And it is accentuated by the tariff barriers that have been raised by all of the succession states, so that baffled by these discriminations from without, Austria is seeking to reduce her import overhead by an intensive waterpower development within her borders. The need is evident when I say that one-half the money expended for imports is devoted to the item of coal, which comes from Silesia, Czecho-Slovakia and the Ruhr. Putting it in another way, in 1922 Austria consumed 9,000,000 tons of coal, of which 6,000,000 had to be imported at a cost of roughly $40,000,000. The country normally needs 15,500,000 tons each twelvemonth.

Austria has nearly 2,500,000 horse power in waterfalls capable of development, and only a ninth of it has been harnessed up. Since the first of this year forty-nine power companies have been organized and the improvement of properties begun. Commercially, the most valuable opportunities are in Upper Austria and Syria, where there are considerable industries and many towns. During July Vienna determined to rid herself of the coal burden and contracted with two big companies for current. About the same time the first electric locomotive went into operation in Austria on a line from Innsbruck to Teefs.

A nation-wide campaign to do it electrically is in full swing in Austria. It is estimated that by fully developing the Austrian water power nearly 3,000,000 tons of coal would be saved by the railroads, 4,500,000 by industry and agriculture and 1,000,000 by households. Altogether a value of $60,000,000 for coal purchase in normal times would be dispensed with.

False Theories on Railway and Agricultural Problems.

The daily press and other current publications still furnish the usual amount of anti-railway propaganda, most of which shows these self-appointed Sir Gallahads to be either densely ignorant or rather careless in their regard for truth, but first, last and always they are against railway interests, even at the expense of doing violence to all sense of justice or equity. The stereotyped demand for reduction in rates, government ownership, etc., being given out to the people with supporting data that will *not* bear analysis. Let us substitute some facts, for a lot of *loose talk.*

An investigator of economic problems and their relation to the railway industry furnishes the following information as to the agricultural industry:

Number of farms in U. S. in 1910......	6,361,502
Value of all farm property in 1910......	$40,991,449,090
Average per farm in 1910.............	6,286
Number of farms in U. S. in 1920......	6,448,502
Value of all farm property in 1920......	77,924,100,338
Average per farm in 1920.............	12,084
Increase in 10 years..................	36,932,661,248

Per cent of increase about 100 or almost 10 per cent per year for ten consecutive years. Yet in the face of these facts the jingo statesmen claim the farmers are busted, and howl about the government guaranteeing the railway 6 per cent when as a matter of fact they do *not* guarantee them any fixed return. These cheap politicians also falsely allege that it is high freight rates that keeps the cost of living so high as to be a burden to all.

It is further stated by the same above mentioned authority on economic problems, that of the products of agriculture there was sold in 1922, for which the farmers received $7,000,000,000, but for which the ultimate consumers paid $22,000,000,000 and the question at once arises, "Who got the $15,000,000,000." The average anti-railway propagandist will at once shout the answer. "The railways get the most of it in their exorbitant freight rates" and a more or less passive public is too willing to believe this sort of rot.

Let us pass this piece of material through the laboratory for analysis and see about how much the railroads did get. If, as some careless handlers of the truth claim, the item of $15,000,000,000 went to the railways to cover excessive freight charges, that amount divided among the 6,448,343 farms, would be about $2,324 to each of the 6,448,343 farms in the U. S., and if that were true it would be a pretty high tribute for the railways to exact from the farmers.

We will see about how much they actually did get.

The entire freight revenues on all lines for 1922 was $3,458,190,626, quite a difference from $15,000,000,000, but this is not the complete answer.

In the commodity division of freight handled by the railways we find that of the total, products of agriculture was 11.58 per cent and of animals 2.51 per cent, or a total of 14.36 per cent, but to be liberal we will place it at 15 per cent, and 15 per cent of $3,458,190,626 is approximately $518,728,593.90. So that instead of the wicked railways exacting an average tribute of about $2,324 from each of the 6,448,343 farms in the form of extortionate freight rates, it would appear that the amount averages about $80, all of which simply goes to show that freight rates are a small factor in the cost to the ultimate consumer, or in the "cost of living," and that relief for the manufacturer and farmer, particularly the latter, lies in directions other than the question of freight rates. In order to prove this last statement we sumbit a few details of actual costs to haul certain articles of wearing apparel from the point of manufacture to the consumer.

A suit of clothes selling for $25 to $50 rides 300 to 400 miles for about..............	6c
A pair of shoes selling for $8 to $12 rides 300 to to 400 miles for about..................	5c
A suit of underwear selling for $1.50 to $5 rides 300 to 400 miles for about...............	1½c
Men's shirts selling for $2 to $6 rides 300 to 400 miles for about.........................	1½c
A hat selling for $2 to $6 rides 300 to 400 miles for about	3c
A pair of men's gloves selling for $2 to $2.50 rides 300 to 400 miles for about..........	9 mills

The list could be extended indefinitely.

The ultimate consumer should not only *know all* these things, but should not go shopping without being fully armed and prepared to "open fire" on the first salesman who qualifies for membership in the Ananias Club by deliberately lying to you about how it would please him to sell this or that article for $1, $2 or $5 less if it were not for the exorbitant freight rates which they most reluctantly are compelled to pay, and pass on the ultimate consumer.

These regularly ordained cheerful liars will look one straight in the face and declare that if they could only get a reduction of 30 per cent in freight rates they could and would gladly reduce the prices, of such articles as listed above, from one half dollar to as much as five dollars, when, as a matter of fact, 30 per cent off the suit of clothes would amount to just 1.8/10 cents, and on the gloves gloves 2.7/10 mills, in fact the amount is so small that in many cases it may be almost ignored as a factor in fixing the selling price.

If the freight on a $40 suit of clothes is 6 cents, why should a dealer who claims that with a reduction in freight of 30 per cent, or 1.8/10 cents, he could and would gladly reduce the selling price $5, be allowed to remain out of jail?

The Transportation Act has been the objective of attack by the old school political railroad baiter, regardless of the fact that under it the people of the United States are getting not only the best but the lowest priced transportation in the world.

Consolidation Type Locomotives for the Reading Company

The heaviest locomotives of the Consolidation type thus far completed by The Baldwin Locomotive Works were built for The Reading Company late in 1923. These locomotives, designated as Class I-10-SA, weigh 314,950 pounds with 284,190 pounds on drivers, and develop a maximum tractive force of 71,000 pounds. A comparison of their principal dimensions with those of previous Consolidations built for this road, shows in a striking manner the increase in capacity effected since 1880. Such a comparison is presented in the following table:—

Date	Cylinders	Drivers	Steam Pressure	Grate area	Water Heating surface	Superheating surface	Weight on drivers	Weight, total engine	Tractive force
1880	20"x24"	50"	120	76	1,357	...	90,300	104,100	19,600
1890	22"x28"	50"	140	76	1,818	...	135,000	150,000	32,250
1900	22"x28"	56"	200	*47.5	2,130	...	147,600	164,300	41,200
1905	22"x30"	61½"	210	90	3,209	...	204,000	226,250	42,200
1919	25"x32"	55½"	200	94.9	2,655	575	250,800	281,100	61,000
1923	27"x32"	61½"	220	94.5	3,315	778	284,190	314,950	71,000

*Designed for burning bituminous coal.

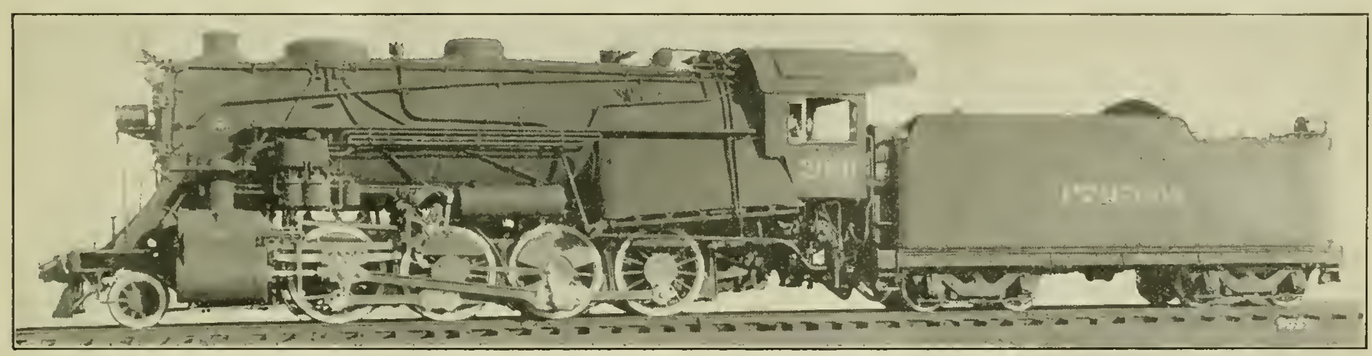
As compared with the locomotives built in 1880, Class I-10-S A shows an increase in total weight of 208 per cent and in tractive force of 262 per cent. With a ratio of adhesion of four, the weight on drivers of the new locomotives is fully utilized for traction purposes.

Fuel and traffic conditions on the Reading are largely responsible for the continued use of the Consolidation type in heavy freight service. The fuel used is a mixture of fine anthracite and bituminous coal, which can be economically burned in a wide firebox placed above the driving wheels; while the traffic consists largely of coal, which is hauled in heavy drags at moderate speeds. With the excellent track conditions on this road, and with generally favorable grades from the mining region to tide-water, eight-coupled locomotives handle the heaviest trains that can be economically operated; and the Consolidation type is meeting the requirements most successfully.

The new locomotives are a direct development of Class I-9, built in 1919, and have many features in common with them. The increase in total weight is 12 per cent and in tractive force 16 per cent. Flanged tires are used on all the wheels, and are spaced tranversely to permit the locomotives to pass curves as sharp as 22 degrees.

The boiler is of the Wootten type, with a conical ring forming the front half of the barrel, and a maximum diameter of 96 inches. The center line is placed 10 feet 2 inches above the rail. The firebox has a combustion chamber, across the throat of which is built a brick wall 26 inches high. A duplex stoker is applied, and the grate is of the rocking pattern, with drop plates front and back. The ash pan has a single hopper of large capacity, with a steam blower pipe for cleaning. A special feature that should be noted in connection with the boiler, is the Economy Front End, as patented by I. A. Seiders, Superintendent of Motive Power and Rolling Equipment of the Reading. The sparks are broken up by means of a "breaker plate," consisting of a slotted plate fitted with deflecting vanes, which is placed under the superheater damper and in front of the tubes. The netting frames are most substantial in construction, and the device has proved very effective in preventing the setting of fires due to escaping sparks.

As in the Class I-9 Consolidation type locomotives, the cylinders are cast separate from the saddle. The valve chambers are bushed for 13-inch piston valves, but are of sufficient size to take valves 14 inches in diameter. The valves are set with a travel of 6-½ inches and a lead of ¼", and have a steam lap of one inch and an exhaust clearance of 1/16". They are operated by Walschaerts gear, controlled by the Ragonnet power reverse mechanism. The pistons have rolled steel heads and cast iron bull rings, and the driving and engine truck axles, crank pins, piston rods, and connecting rods are of quenched and tempered steel; the driving axles being hollow bored. Fifty per cent of the reciprocating weight is balanced.



Heavy Consolidation or 2-8-0 Type Locomotive of the Philadelphia and Reading Railroad—Built by the Baldwin Locomotive Works

Two of the locomotives in the group are equipped with the Sellers exhaust steam injector.

The main frames are each cast in one piece, and with the transverse braces are of most substantial construction. The front frame sections are in the form of slabs, which fit between the central saddle and the cylinder castings. The main driving boxes are of the extended type, and self-adjusting wedges are used on the main pedestals.

The tender frame is built up, with 10 and 12-inch longitudinal channels and steel plate bumpers. The tank carries 9,500 gallons of water and 15 tons of coal. The trucks are of the equalized pedestal type, with forged steel wheels.

These locomotives have a width over the cylinders of 10 feet 5 inches, and a height overall of 15 feet 4-5/8 inches. Further particulars are given in the table of dimensions.

Gauge	4 ft. 8½ in.
Cylinders	27 in. by 32 in.
Valves—Piston	13 in. diam.
Tractive force	71,000 lb.
Service	Freight
Boiler:	
Type	Conical
Diameter	88 in.
Working pressure	220 lb.
Fuel	Hard and soft coal mixed

Firebox:		
Material		Steel
Staying		Radial
Length		126⅜ in.
Width		108¼ in.
Depth, front		79 in.
Depth, back		65 in.
Tubes:		
Diameter	5⅜ in.	2 in.
Number	50	291
Length	13 ft. 6 in.	13 ft. 6 in.
Heating Surface:		
Firebox		236 sq. ft.
Combustion chamber		91 sq. ft.
Tubes		2,988 sq. ft.
Firebrick Tubes:		
Total		3,315 sq. ft.
Superheater		778 sq. ft.
Grate area		94.5 sq. ft.
Driving Wheels:		
Diameter, outside		61½ in.
Diameter, center		54½ in.
Journals, main		12 in. by 18 in.
Journals, others		11 in. by 13 in.
Engine Truck Wheels:		
Diameter, front		33 in.
Journals		7 in. by 11 in.
Diameter, back		
Journals		
Wheel Base:		
Driving		77 ft. 6 in.
Rigid		77 ft. 6 in.
Total engine		27 ft. 6 in.
Total engine and tender		66 ft. 10¾ in.
Weight (Working Order):		
On driving wheels		284,190 lb.
On truck, front		30,760 lb.
On truck, back		
Total engine		314,950 lb.
Total engine and tender		502,000 lb.
Tender:		
Wheels, number		8
Wheels, diameter		36 in.
Journals		6 in. by 11 in.
Tank capacity		9,500 U. S. gal.
Fuel capacity		15 tons.

Equipped with superheater, stoker, power reverse and air brake on all driving and tender wheels, with one 8½ in. cross compound pump.

I. C. C. Holds Hearing on Automatic Train Control

The railroads affected by the Interstate Commerce Commission's order of January 14th to make installations of automatic train control were given an opportunity on May 7th to show cause why the order should be annulled or modified. W. J. Harahan, president of the Chesapeake & Ohio and of the Hocking Valley Railroad Companies, who is chairman of a committee named by the railroads, in a general statement outlined the position of the railroads and proposed three regional tests on 100 miles of line in each region.

Warren S. Stone, grand chief of the Brotherhood of Locomotive Engineers, and J. F. Welch, mechanical editor of the Official Organ of the Brotherhood, also strongly opposed the installation of any type of device because it would result in divided responsibility for the operation of trains. Mr. Stone declared the greatest tragedy in the destruction of human life in railroad history had yet to be written and that it would be written when the railroads divided the responsibility of running a train between the engineer and an automatic train control device.

The general position of the roads was outlined in Mr. Harahan's statement, an abstract of which follows:

The railroads feel that if the orders of the Commission, issued June 13, 1922, and January 14, 1924, are insisted upon it will cause them to spend money which will not bring about as much safety in operation as will be the case if they are allowed to spend this money in other directions, and that much of the money so spent would be wasted, because of the crude state of the art of train control. Many individual roads are utterly unable to determine, in view of their financial needs for safety and other imperative purposes, how they can obtain the money necessary to carry out these orders.

Automatic Control in the Experimental Stage

Many railroad technical and executive officers feel quite strongly that automatic train control is still in the experimental stage. There are none who feel that it has passed what may be known as the development stage, and this does not mean the development of the smaller niceties or details of operation, but means much development of an important nature.

It may be urged by some that the railroads are seeking to place money before safety. This is not true, but there is a practical feature in the provision of money for the various needs in the operation and expansion of the railroads that cannot be brushed aside. Of course the more money a railroad has left after all interest and dividend requirements are met, the greater its ability to obtain capital for the improvements necessary to obtain safe and economical operation and to provide facilities necessary for the Country's expansion.

The railroad executive is thus confronted with the necessity of applying the money obtained from operation, together with that obtained from the judicious sale of securities, in that way which will enable him to obtain the most productive results.

There are many improvements which the Commission would no doubt like to have made, and which the railroads would like to do, but the money is not there to do it, so business discrimination has to be used in selecting the purposes for which the money available is to be spent.

The railroads would like to eliminate as many grade crossings as they possibly can.

The number of persons killed at grade crossings per annum is many, many times the number of passengers and employes whose lives will be saved by the use of train control.

The railroads cannot eliminate all of the grade crossings at once because they cannot obtain the money to do so. They can only take the most hazardous ones and eliminate them a few at a time with the money that is available.

It is the desire of the railroad executives to spend the money along the lines which will produce the greatest safety and consequently they do not look with favor upon putting vast sums upon a device which is yet in its infancy. They would much prefer to invest an equivalent amount of money in automatic block signals, rather than in this undeveloped device.

Automatic train control is designed to protect against most unusual occurrences. It will not prevent all collisions. On the other hand automatic block signals protect against occurences which are likely to take place any day, anywhere. We cannot have both, because the people will not allow us to charge sufficient rates to provide this, together with the improvements necessary for the country's expansion.

Few railroad presidents; I may say none, have felt satisfied that any practical thing had been offered. I believe that any business man and any member of the Interstate Commerce Commission, finding themselves so situated, would have taken the same attitude toward this proposition.

I am sure that train control will cost a far larger amount of money than was at first anticipated by the Commission. Our engineers advise us that it will cost somewhere near the following to put in a train control system that may or may not carry out the intention for which it is designed: Where automatics are already in use, $3,000 per mile. Where there are no automatics, to install automatics and train control, $6,700 per mile. Installation of train control alone, without automatics, $5,000 per mile.

I have heard some well-informed men argue that we are running up the cost of automatic train control by attempting entirely too elaborate a proposition, and it is suggested that what we should do is simply to place a device at a point where a signal is located, or find some means whereby the air will be automatically applied if the engineer does not do so at the point where he should. We cannot carry out the requirements of the Interstate Commerce Commission, as I understand it, with such an installation as this.

Danger on Heavy Grades

I am afraid that upon heavy grades there will be introduced far greater dangers than are now encountered without train control, particularly on railroads handling very heavy trains, because the question of the exhaustion of air will present a real danger. Every engineer has a different method of handling the air on his train. Every train requires a different method of handling. You cannot substitute a machine which will act in the same way as will the human brain and human skill.

There is another very serious feature:—Taking from the trainmen responsibility of controlling their trains and thus putting them in the position of taking chances, which they would not take if they knew that the whole responsibility was upon them. In that the brakes are going to be applied automatically it is likely that they will take chances, and if they will take chances of this kind they may take chances in other directions. The Transportation Act encourages the consolidation of railroads into a smaller number of systems. It also quite clearly seeks to encourage the joint use of facilities by railroads, so that the feature of interchangeability of devices becomes an important one.

The railroads desire to co-operate, in working out a proper system of train control, but they feel most emphatically that it is not necessary to equip 16,000 miles of railroad, which will require the expenditure of perhaps $102,000,000, at least calculation. We submit, just as strongly as we know how, that for the same money a much greater amount of safety can be had, also adding to the capacity of the railroads.

Decreases Capacity Delaying Traffic

Automatic train control, in its present stage decreases the capacity of railroads by the introduction of unnecessary stoppages, running slowly, etc., as compared with present practices.

It is earnestly suggested that train control can be worked up to a sufficient stage of development if, instead of the colossal trial which has been ordered by the Commission there be selected a certain number of miles in the Eastern, Southern and Western regions, under all conditions of density of traffic, heavy grades, weather and all the other factors necessary to be overcome. It is thought that 100 miles in each region, located on various railroads and in places where the most severe tests could be had, would be adequate, costing the railroads over $2,000,000.

There should be a minimum traffic, below which railroads should not be required to equip their lines with these devices, and experiments should be had so as to determine whether a simple device can be obtained with which such railroads could equip themselves. On many lines of light traffic it would cost them a large proportion of the original cost of their lines if they had to equip them with the devices known today.

The Chesapeake & Ohio has been experimenting with automatic train control since 1916—8 years. It now has 61 miles of the "ramp" device in operation. It has spent for purposes of development, including the cost of the apparatus, over $8,000 per mile; yet in spite of this record of eight years this company must yet admit it does not possess an automatic train control system which satisfies it. It does not meet the I. C. C. requirements.

For the year ended March, 1924, the average number of operations to each failure was about 2,654, whereas the average number of operations per failure of automatic block signals in that same territory was 16,891. The signal engineers advise that there are many roads that have obtained at least twice as many operations per failure for the automatic block signals, as above shown.

I call your attention to certain statements made in petition addressed to you by the railroad executives, as follows:

"That as no revenue will be received on account of such investment the only way in which such decrease can be made up is by an increase in the passenger rates, or the freight rates, or both, of the several carriers, and that no provision has as yet been made for such increase, or for determining what the percentage of such increase shall be; and that said expenditure will result in no assurance of the securing of additional safety in the operation of the railroads of such carriers, but will involve the possibility of added danger to such operation of the railroads by reason of the installation and operation of such devices."

We, who operate the railroads, are responsible, both by the Transportation Act, 1920, and at the bar of public opinion, for honest, efficient and economical operation. We should have the power to fulfill that responsibility.

Samuel Rea, president of the Pennsylvania System, although agreeing with Mr. Harahan, emphasized the need of the railroads spending their money for the elimination of grade crossings instead of experimenting with automatic train control devices. He placed his road on record as favoring a program of co-operation and co-ordination between the carriers and the various States in this regard.

Locomotive Performance on the Southern Pacific

Four sections of the Sunset Limited and six sections of the Golden State Limited, making ten trains in all, left Los Angeles on May 22, 1924, each train being hauled by one of the Southern Pacific's new mountain type locomotives all the way through from Los Angeles to El Paso, distance 815 miles. No trouble was experienced, and all ten of these trains arrived at El Paso on time.

On the same day the Overland Limited, consisting of three sections, left San Francisco carrying passengers on the first day of the summer tourist rate excursions; each section being hauled by one of the new mountain type locomotives, and every section arrived on time at Ogden; and furthermore, arrived on time at Omaha, the terminus of U. P. R. R. Co. and at Chicago, the destination.

The Overland Limited, consisting of twelve cars, is now hauled regularly over the Sierra Nevada mountains, with maximum grades of 116 feet to the mile, with one of the Southern Pacific's new freight locomotives (2-10-2) with no helper locomotive.

Service for Exporters of Railway Material

The Commercial Intelligence Division of the Department of Commerce has just announced a series of new Trade Lists of interest to exporters of railway material. These lists contain the names of importers and dealers in railway material in foreign countries and may be had without charge from any of the district or co-operative offices of the Bureau of Foreign and Domestic Commerce or from Washington.

The Development of the Electric Locomotive

By A. H. ARMSTRONG

A Paper Presented at the Railroad Session of the Spring Meeting of the American Society of Mechanical Engineers

The first lesson learned by the electrical designer was the thought that the successful conception of an electric locomotive did not consist in the simple substitution of the electric motor for the steam cylinder and the adoption of the running gear accepted as good practice after many years of steam engine development. This in no way implies a criticism of steam engine construction which is admirably suited to its purpose under the limitations imposed by engine, boiler and fire-box design. Just as these fundamental parts of the steam engine determine both its construction and service performance, so the electric motor, with its great flexibility, permits a radical departure from steam engine practice in both the design and operating characteristics of the electric locomotive.

A study of the running gear of electric locomotives now in operation discloses many forms of drive ranging from single gear, twin gear, side rod and jack shaft, geared side rod, quill geared, and finally gearless drive with motor armature mounted directly upon the driving axle. With any one form of the above drives there is also offered a wide variety of wheel and cab arrangement. No one design of electrical or mechanical construction has yet been universally accepted as a standard to the exclusion of others, although this is the desirable goal toward which the efforts of the designing engineer are constantly directed.

With such a diversity in forms of construction shown in electric locomotives now running, it is the purpose of this paper to discuss in a general way some of the fundamental principles of design which have found favor as the result of the past thirty years development.

Double End Operation

With apparently no exception, the first radical departure from steam practice was made when electric locomotives were designed for equally good operation in either direction, in other words, by providing a symmetrical arrangement of running gear so that locomotives could be operated double ended. The absence of boiler and fire-box makes this accomplishment possible and the operating convenience of eliminating the turn table and wye can be taken full advantage of without imposing a too serious burden upon the electric locomotive designer. In order that the locomotive operator may command an uninterrupted view of the track ahead, cabs are built of two general designs, the so called "steeple" cab with sloping ends and one operating compartment and the box type cab with two operating compartments, one at each end. As the motor control of large electric locomotives is effected through indirect or master controllers which can be located in one or more places, it is possible to design the operating cab for the most convenient handling of the locomotive, and provide one or more operating handles as conditions may demand.

Chicago, Milwaukee & St. Paul High Speed Gearless Electric Passenger Locomotive

The adoption of a symmetrical wheel arrangement, which permits running equally well in either direction, introduces no difficulties in the construction of locomotives which will run below a speed of 50 miles per hour. In other words, the tracking qualities of an electric locomotive do not become a matter of serious concern to the designer, until entering upon the field of the passenger locomotive which must have good running qualities up to maximum speeds of 75 miles or possibly more. Few, if any, steam engines will operate successfully in reverse direction and in providing this feature of electric locomotives the designer has had to solve new problems without much assistance from steam engine operating experience. That such problems have been successfully met is attested by the daily operation of electric locomotives in high speed passenger train service with less apparent destructive effect on track than is normal with steam engine operation.

Electrical and Mechanical Designs

The mechanical construction of an electric locomotive is so dependent upon the characteristics of its motors and control that the complete electrical and mechanical design must be treated as one problem. For example, geared motors suspended upon driving axle and bolster must conform to the restricted space imposed by track gauge, wheel diameter, and permissible wheel base of driving truck. These limitations do not seriously restrict the free design of motors geared to small capacity driving axles but force a departure from geared axle drive in the case of certain types of motors, when axle weights must exceed 40,000 pounds. As an illustration, direct current motors drive the 56,000 pound axle on the C. M. and St. P. freight locomotives, but it would be impossible to replace them with an equally successful single phase alternating current motor on account of the greater space required for the proper proportioning of the latter type of motor. It would also be impossible to replace the gearless direct current motors on the New York Central, C. M. and St. P. passenger and Paris Orleans locomotives with alternating current motors, as bipolar gearless drive is available only to motors of the direct current type. On the other hand, all forms of construction open to alternating current motors are equally available to the direct current motor.

As both direct current and alternating current types of motors have been utilized to drive electric locomotives and all forms of drive are not equally available to both, more or less confusion has been introduced into the problem of arriving at a preferred form of mechanical design which might be generally adopted and possibly become a recognized standard. A thorough knowledge of electric motor characteristics is therefore desirable, to arrive at any conclusion in respect to the superiority of any particular mechanical design of locomotive in order to judge whether it possesses inherently the advantages sought for or whether its adoption may have been forced by the limitations of the type of motor used.

General Comparison Steam and Electric Locomotives

The steam engine is a mobile power house complete with fire-box, boiler, engine and operating crew. In order that the latter may be used to the best economic advantage, every effort has been made to build engines of greater power. In this Country of almost unlimited fuel supply, not much serious effort has been made until recently, to improve the fuel economy of steam engine performance except as it might increase the maximum weight and speed of trains hauled. In other words, with cheap and abundant fuel and high priced labor the matter of fuel economy has been secondary to the insistent demand for engines of greater hauling power and speed.

As each steam engine must necessarily be operated by its own crew and as the improvements made in the modern draft gear permit the operation of trains on ruling grades beyond the hauling capacity of a single engine, it is a logical development that the steam engine should be built with a maximum number of driving axles and maximum weight per axle. Hence, the construction of the Mikado, the 2-10-2 and the Mallet, with axle weights in some instances of approximately 70,000 pounds to meet the necessities of constantly increasing traffic. The logical development of the steam engine, therefore, lies apparently in the direction of the maximum driving axle weight that improved rail and road bed may permit and the maxium number of axles that can be concentrated in one structure and operated by one crew without exceeding wheel base restrictions imposed by track curvature.

It is of importance in determining electric locomotive design to carefully analyze the fundamental reasons for modern steam engine construction, with which electric locomotives are naturally compared, so that hard steam engine experience shall be taken advantage of to the fullest extent. Unlike the steam engine, the electric locomotive carries no power plant. Furthermore, the electric motor is wonderfully adaptable in its application to axle drive and small motors are practically as efficient as large ones. These valuable assets make it possible to design an electric locomotive for its sole fundamental purpose of hauling trains with reliability and economy. The same factors shaping the design of running gear of steam engines do not apply equally to electric locomotives and both in its operation and construction, the latter can, with advantage, depart widely from steam engine precedent. Neither the wheel arrangement, side rod drive, or excessive axle weights characterizing the modern steam engine are fundamentally necessary to the construction of a successful electric locomotive and they need only be accepted on their merits. With the new freedom thus offered it is natural that the experimental field of promising designs should have been quite fully explored with the resulting wide divergence in mechanical and electrical construction shown in electric locomotives now in operation. The electric locomotive may be built up of any number of driving axles, all under the perfect control of one operator and there are no electrical, mechanical or economic limits in respect to its size, hauling capacity and speed, except those imposed by the road bed itself.

With the above general comments in mind, perhaps a better understanding of the progress of electric locomotive development may be obtained by reviewing the construction of a number of recent designs that have been built.

There are four types of drive used in electric locomotive construction and each has certain advantages peculiar to itself: Geared axle drive, Geared quill drive, Jack shaft and side rod drive, Gearless drive.

Geared Axle Drive

As the electric locomotive was the outgrowth of experience in motor car construction, it was evident that the earliest designs should comprise an operating cab resting on two swivel trucks, a motor being geared to each of the four driving axles. This type of drive has been uniformly successful and is generally accepted today as standard for locomotives where axle weights are not excessive. An example of this type of construction is shown in the C. M. and St. P. 70 ton switching locomotive, equipped with direct current motors and operating from 3,000 volts direct current trolley. The same type of construction is also available to single phase or multiphase alternating current motors, provided the axle weights in the former case do not much exceed 40,000 pounds. The single phase motor requires more space for a given output and speed than a direct current motor and is therefore limited in its application to geared axle drive to moderate axle weights, especially if the locomotive must fulfill a service demanding a high continuous tractive effort. This fact accounts in part for the greater favor shown quill and side rod construction in single phase motor locomotives of larger capacity.

Direct current motors are in successful operation driving through single gears axle weights of 40,000 lbs. and through twin gears, a maximum of approximately 60,000 lbs., as exemplified in Detroit River Tunnel, Baltimore & Ohio Tunnel, and C. M. & St. P. freight locomotives. There are no apparent reasons why twin geared drive should not prove successful with axle weights exceeding 60,000 lb., although no such locomotives are now in operation. In order that stresses between the two gears may be equalized and to cushion the motor from impact transmitted through the gears from inequalities in the track, it has been found advantageous to interpose a small amount of spring controlled motion between the gear rims and their centers. This construction in no way resembles geared quill drive as cushion gear rims are mounted concentric with their centers and in intimate contract with them. The success attending the operation of spring or cushion gears has broadened the application of geared axle drive.

Four Motor Geared Locomotives

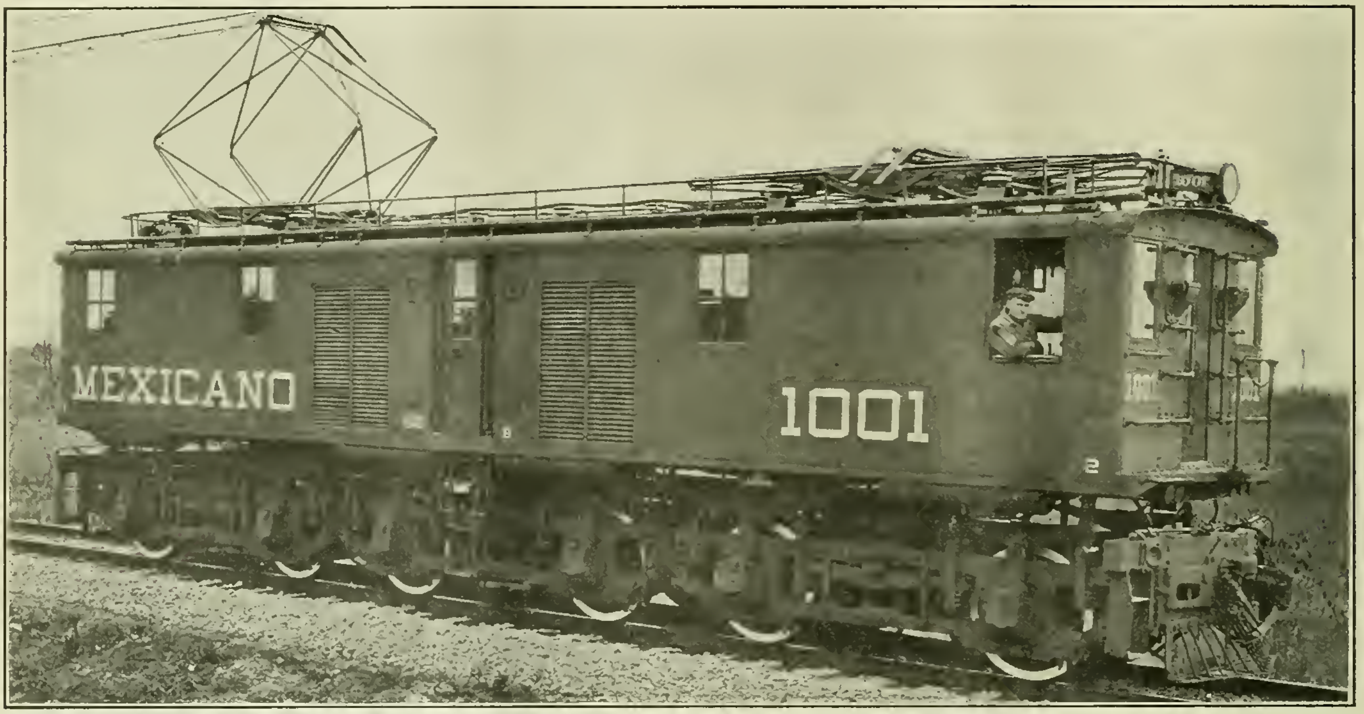
While swivel truck construction, with the draft gear forming an integral part of the cab subframe, operates entirely successfully with moderate axle weights, it has been considered good practice, in some instances, to introduce articulated truck construction in heavier locomotives. Good examples of four motor twin geared articulated truck locomotives are presented in the Detroit River Tunnel, Baltimore & Ohio Tunnel, Great Northern, Butte, Anaconda & Pacific, Bethlehem Chili Iron Mines and Canadian Northern locomotives. The trend of design in the larger locomotive is apparently in the direction of box cabs with operating compartment in each end.

The maximum speed of four axle locomotives of the heavier type has usually been limited to approximately 50 miles per hour and no impairment of good tracking qualities has been experienced within this limitation. Undoubtedly higher speeds are permissible with four axle bogie truck locomotives but as yet the limitations have not been fully determined. This type of design is very attractive, owing to its simple and rugged construction and the opportunity it offers to combine several such four motor units into one locomotive of any capacity desired. Both from an operating and manufacturing point of view the four motor swivel truck locomotive promises attractive possibilities of meeting a wide range of service requirements with but few types of locomotives which could be so generally applicable to average service conditions as to be standardized, a result most earnestly desired by all.

Six Motor Locomotives

Two locomotives have been built and tested in which six motors are geared to the six driving axles, all the weight of the locomotive being upon the drivers. The wheel arrangement is quite different in the two locomotives and each offers an attractive application of motors geared direct to driving axles of moderate weight.

The Spanish Northern locomotive, weighing 90 tons, has its cab mounted upon two three-axle swivel trucks. The motors are of the direct current type and operate from 3,000 volt trolley. In this instance the adoption of a three-axle truck permitted the construction of a powerful compact locomotive having 179,000 lbs. total on its drivers without exceeding a weight of 30,000 lbs. per axle. It is capable of delivering continuously a tractive effort of 26,500 lbs. at 21.9 miles per hour. The Spanish Northern locomotive has just been put into operation and will be used to handle ore trains and incidental passenger service. It is provided with regenerative braking control.



Six Axle Geared Electric Locomotive of the Mexican Railway

The Mexican Railway locomotive comprises 6 motors twin geared to six driving axles arranged in three four wheel articulated trucks. The cab is supported upon two sub-frames sharing a common center on the middle truck. These sub-frames are of boxed girder construction which provides a ready passage through which air is forced to cool the individual motors. In this locomotive the axle weight is 51,500 lbs. and the total weight of the locomotive 309,000 lbs., all the weight being upon the drivers. Provision is made for regenerative braking. This locomotive has been built and exhaustively tested upon the Erie test track.

Six axle geared motor locomotives offer the advantage over four motor construction of fifty percent greater capacity, or a lower axle weight to meet special conditions of track and structures or type of motor adopted. Six motor geared axle construction is available to both direct current and single phase alternating current motors with the restriction in the latter type that axle weights cannot greatly exceed 40,000 lbs.

Eight Motor Geared Locomotives

In order to meet the demands for locomotives of very large capacity or to provide for minimum driving axle weight, eight driving motors may be utilized to good advantage. Motors may drive either through single or twin gears depending upon axle weights and trucks may be articulated or stresses taken through cab sub-frame, as desired.

The simplest form of eight motor locomotive is obtained by coupling two four motor bogie truck locomotives together, the eight driving axles being operated as a single locomotive by means of multiple unit control. Two of the B., A. & P., 81-ton locomotives are thus permanently connected together and operate as a single 162-ton locomotive, under the control of one engineer. Where axle weights and speeds are not excessive this type of construction is regarded very favorably by many engineers and operating records attest its reliability and low cost of upkeep.

A good example of an eight motor geared construction is offered in the C., M. & St. P., 3000 volt direct current freight locomotive which comprises four two axle articulated bogie trucks and two four wheel guiding trucks supporting two operating cabs. These locomotives are capable of delivering continuously a tractive effort of 79,500 lb., at a speed of 15.4 miles per hour, and have been in successful operation since December, 1915. The St. Paul locomotive was the first to be equipped with regenerative electric braking which is now accepted as a desirable addition to electric locomotives operating over mountain grades. As twelve of the St. Paul geared locomotives were originally supplied with high speed gearing and used in passenger service at speeds up to 60 miles per hour, bogie guiding trucks were added to all locomotives for the sake of interchangeability, although the better tracking qualities thus secured may not have been necessary if these locomotives had been restricted to freight duty only. While an axle load of 60,000 lbs. was regarded by some engineers in the past as possibly too high for leading and trailing axles, continued development of both steam and electric locomotives has somewhat modified opinions in this connection. Electric locomotives are in daily successful operation with 60,000 lb. per driving axle and no additional axles and it is apparent that an eight motor geared locomotive, weighing 480,000 lbs., total, will undoubtedly operate successfully with all weight distributed upon the drivers provided the locomotive operation is restricted to freight train speeds.

Twelve Motor Geared Locomotives

The development of this type of locomotive has not proceeded very far owing to the fact that the combined axle weight of eight geared motors is usually ample to meet the requirements of the heaviest freight service. However, it is intended to operate two of the Mexican Railway locomotives coupled together, thus providing 618,000 lb. on driving axles and a continuous tractive effort of 92,400 lb. Starting effort at 30 coefficient of adhesion will reach the high value of 185,400 lb., and this is probably the maximum limit allowable in road engines hauling miscellaneous freight cars with present design of draft gear. There is, of course, no restriction in the locomotives themselves against coupling in one operating unit even more axles and still greater weight for operation in very special ore train service.

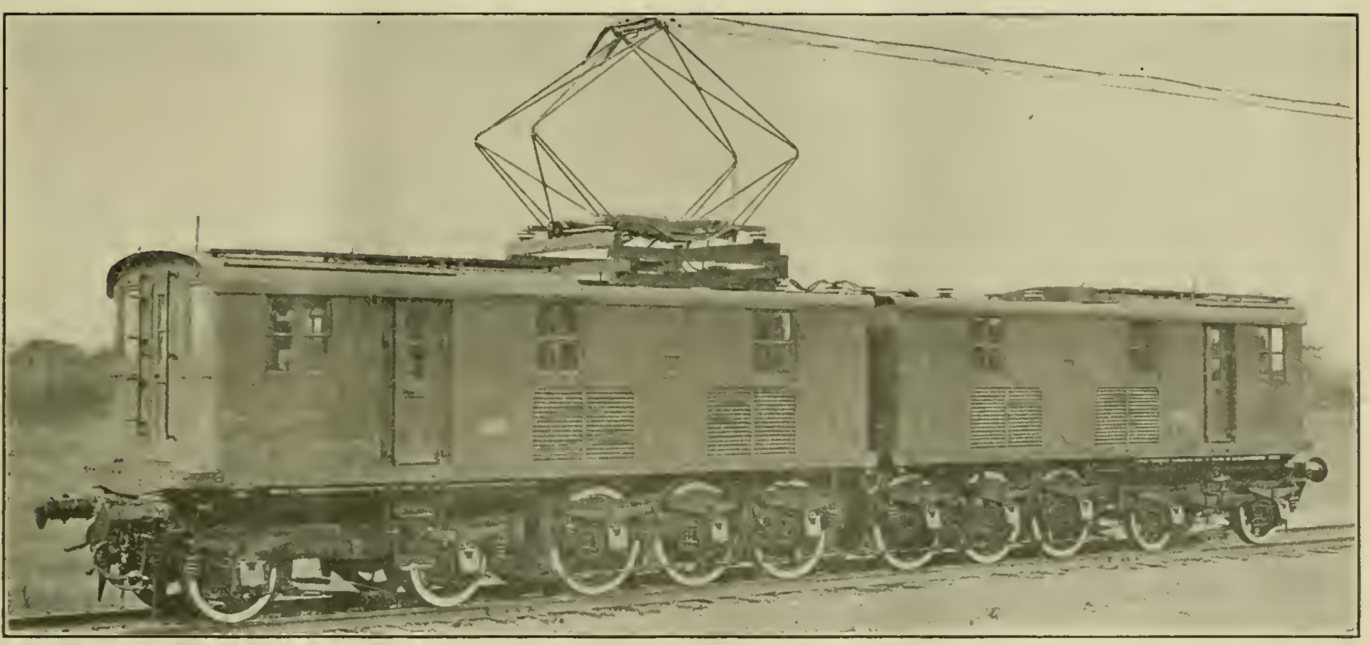
The entire range requirements of freight train service from light to the heaviest can be admirably met with geared motor drive and there is every reason to expect this type of construction to hold a preferred position in locomotive design in the future.

Gear Quill Drive

This form of construction is more especially favored when single phase alternating current motors are applied to axle weights beyond the capacity of single motors mounted in conventional manner with geared axle drive. It offers the advantage of supporting all motor weight on springs, high clearance over the rails, and permits the use of two motors driving the same gear and thus providing the additional output per driving axle required. The disadvantage of this form of drive has been the spring and wheel spoke failures in the past due to excessive strains introduced by the difficulty of maintaining the quill reasonably concentric with the driving axle.

Side Rod Drive

As with geared quill drive, side rod drive also offers the advantage of carrying all motor weights on springs, providing maximum clearance between motor and rails and raising center of gravity of locomotive with whatever better riding qualities may result therefrom. Many forms of side rod drive have been built experimentally, but not duplicated. Geared side rod drive, in which one or two motors are geared to the jack shaft which connects with the driving axles through side rods, has apparently been accepted in this Country as the most promising form of



Six Motor Bipolar Gearless Electric Locomotive of the Paris Orleans Railway side rod construction. An example of geared side rod drive is offered in the locomotive built by the G. E. Company and in operation upon the New York, New Haven and Hartford Railroad. It comprises four single phase alternating current motors, each geared to a separate jack shaft which drives through side rods a single pair of driving wheels. This locomotive has a continuous rating of 22,200 lb. at 26.4 m. p. h. The driving axles are supplemented by two four wheel bogie guiding trucks which assist in carrying the excess weight of motors, transformers and jack shafts, a usual feature of side rod construction. The reason that side rod drive was adopted in this instance was because it did not seem feasible to equip a locomotive of this capacity with four single phase motors geared to the driving axles in the usual way.

Many other forms of side rod drive and wheel arrangement have been built and apparently the natural development of this form of construction is toward very high driving axle weights and the addition of guiding axles to support part of the weight of electrical equipment and jack shaft and to provide better riding qualities of the locomotive. Side rod drive apparently offers greater advantages to the use of single phase motors than direct current motors owing to the space limitations of the former when applied to heavy driving axles.

Gearless Motor Drive

Another form of six motor locomotive is illustrated in the Paris Orleans bi-polar gearless locomotive recently built and shipped to France. This locomotive comprises six direct current motors with armatures mounted directly upon the driving axles and operates from a 1500 volt direct current trolley. The locomotive comprises two operating cabs each resting upon a three axle driving truck integral therewith and a hinged four wheel guiding truck containing no motors. This locomotive is intended for passenger service and was designed with the view of meeting any reasonable speed requirements incident to such service. The tests at Erie, therefore, were carried beyond the contract obligation of successful running at 82 miles and maximum speeds reaching 105 miles per hour were attained, without developing any evidence of destructive action on track. While the complete locomotive is of symmetrical design and provides for double end running, it comprises two unsymmetrical halves and is equivalent to coupling two Pacific type steam engines back to back.

Gearless motor construction provides a maximum of simplicity and efficiency in locomotive design and operation owing to the entire absence of motor and axle bearings, gears, quills, jack shaft, side rod or other means of connecting motors to driving axles used in other types of locomotives. The first example of the fore-runner of this construction was offered in the original Baltimore and Ohio Tunnel locomotive built in 1893. The direct current motor in this instance, however, was six-pole and was mounted on a quill supported on the driving wheels by rubber cushions. The first example of a modern bi-polar gearless locomotive was the S type construction built for the New York Central Railroad in 1905, 47 of which are still in daily operation. These locomotives comprise four gearless driving axles with a four wheel swivel guiding truck at each end. A later type of gearless construction utilizing 8 motors and all weight on the drivers is shown in the T type of locomotive of which 26 are in operation. This type of locomotive has a high operating efficiency owing to absence of all driving mechanism and the records of 18 years operation disclose a most attractively low cost of maintenance.

Another example of gearless motor construction is presented in the 3000 volt direct current passenger locomotives in service upon the Cascade Division of the St. Paul electrification. This locomotive comprises 12 driving axles and 2 guiding axles, the total weight on drivers being 458,000 lb. This is another example of a symmetrical locomotive composed of two unsymmetrical halves articulated back to back. A novel way of meeting the exacting requirements of boiler installation to heat the passenger train is shown in the heating tender interposed between the two operating cabs. This arrangement gives ample space for a conservatively designed heating boiler and permits the removal of the entire cab in case of necessity. This locomotive provides for regenerative braking.

Gearless motor construction is the simplest form of drive that it is possible to use in the electric locomotive. It offers particular advantages in high speed passenger locomotive service, owing to its high efficiency maintained over its entire working range, its freedom from speed restrictions and its adaptability to any wheel arrangement best suited to easy riding at high speeds. The efficiency of the gearless motor is above 90 per cent throughout the greater part of its working range and this fact holds attractive promise of power economy in operating a service where the low average load factor of a locomotive hauling a fixed load over a broken profile might prove a handicap to other forms of motor drive.

Electric Locomotive Rating

There are two fundamental factors which determine the tractive effort rating of electric locomotives—first, slipping of driving wheels, and second, heating of motors.

It is well known that the coefficient of adhesion between driving wheels and rails varies over a wide range, depending upon the condition of both. Experimental tests made to determine the starting coefficient of adhesion of electric locomotives has established values ranging from over 40 per cent under almost perfect conditions to as low as 10 per cent or even less when rail is covered with sleet or snow. By the use of sand, the handicap of poor rail conditions may be partly overcome. Test records of coefficient of adhesion apply, however, only to the local conditions under which they were taken and it is probably more conservative to accept the general values established in this respect by steam engine practice on ruling grades. A study of many train dispatcher's sheets, showing trailong and engine tonnage actually hauled by engines of different types, indicate that the total gross tractive effort exerted at the driver rims agrees approximately to 18 per cent of the total driver weight. Starting effort is in excess of this value and may reach as high as 25 per cent or even 30 per cent under favorable conditions. It is recognized therefore that electric locomotives for road service should be capable of exerting a tractive effort of approximately 18 per cent of driver weight at balanced speeds on ruling gradients and 30 per cent coefficient of adhesion when starting train.

The problem of motor construction is to keep it within safe temperature limits and safeguard its insulation. As there is a considerable time lag between load and maximum temperature reached, it is apparent that the duration of the load determines its amount. Hence a motor that may operate continuously at a tractive effort rating of 16 per cent coefficient of adhesion with a temperature rise of 120 deg. C may nevertheless deliver double the output during the short time interval required for starting the train. Hence, it is useful to know both the continuous tractive effort rating of a locomotive and its rating for short periods of time, especially if it is to operate over a profile of short ruling gradients on which the motors may be properly called upon to deliver more than their continuous rating. The continuous rating of many of the electric locomotives now in operation are given in the following tables.

CONTINUOUS TRACTIVE EFFORT RATING EXPRESSED IN TERMS OF DRIVER WEIGHT

FREIGHT

	Tractive Effort	Coeff. of Adhesion
Bethlehem Chile Iron Mines	35,200 lb.	14.7%
Boston and Maine	21,000 "	9.7%
Butte, Anaconda and Pacific	25,000 "	15.6%
Chicago, Milwaukee and St. Paul	79,500 "	17.65%
Great Northern	34,800 "	15.1%
Mexican	46,200 "	14.65%
New York, New Haven and Hartford	17,000 "	10.3%
Norfolk and Western	66,000 "	14.5%
Paulista	27,300 "	13.65%
Spanish Northern	26,500 "	14.8%
Average		14.06%

PASSENGER

Butte, Anaconda and Pacific	15,600 lb.	9.7%
Chicago, Milwaukee and St. Paul (10200)	41,000 "	8.9%
Chicago, Milwaukee and St. Paul (10300)	41,000 "	12.1%
New York Central S Type	5,000 "	3.55%
New York Central T type	14,000 "	5.28%
New York, New Haven and Hartford (01)	6,400 "	3.8%
New York, New Haven and Hartford (0300)	14,500 "	6.2%
Paulista	13,900 "	8.7%
Paris Orleans	13,650 "	8.1%
Average		7.35%

SWITCHING

Baltimore and Ohio	13,000 lb.	6.5%
Canadian Northern	16,200 "	10.1%
Chicago, Milwaukee and St. Paul	14,000 "	9.8%
Grand Trunk	37,000 "	14%
Michigan Central	18,000 "	7.5%
New York, New Haven and Hartford (0200)	14,800 "	9.3%
Average		9.53%

While the electric freight locomotives are operated over a wide variety of profiles and service conditions, it is instructive to note the reasonably close agreement of individual tractive effort ratings to the average of 14.06 per cent of the weight upon the drivers. There is more divergence in ratings of passenger locomotives, largely explained by nature of profile, schedule and type of motor, geared or gearless, the latter having a materially greater time lag between load and temperature rise than modern air cooled geared motors.

Conclusion

The general discussion of electric locomotives in this paper has been more especially devoted to the subjects of wheel arrangement and form of motor drive rather than to types of electrical equipment.

Wheel arrangement is, apparently, not a matter of much concern in its effect on riding qualities of the electric locomotive for speeds below 50 miles per hour, in other words, the field of the freight locomotive. For the higher speeds incident to passenger train operation, a four truck construction has found favor on account of its minimum effect upon track and low flange wear.

There are, apparently, two broad lines being followed in the development of the electric locomotive. First, direct application of the motor to the driving axle and, second, the inter-position of jack shaft and side rods.

Geared axle drive for lower speeds and both geared axle and gearless drive for higher speeds have been so successful in meeting every railroad operating requirement that they may be regarded as accepted standards with direct current motor equipment. The bi-polar gearless motor drive is restricted to direct current motors, but geared axle drive is available to both direct current and alternating current motors provided the axle weight in the latter case does not much exceed 40,000 lbs.

Geared quill and geared side rod drive are favored for single-phase motor application to heavy duty locomotives, as providing the additional space required for the best design of such motors. The latter construction, especially, apparently finds its best expression in very high driving axle weights and long rigid driving wheel base, thus possibly restricting the application of such locomotives to roadbeds most favorable for their operation. These same forms of construction are also open to direct current motor applications but apparently find little favor as compared to the simpler and more efficient direct axle drive which is employed in nearly every electric locomotive equipped with direct current motors.

Program for Mechanical Division Convention of the A. R. A.

Division V—Mechanical, American Railway Association, will hold its annual meeting at Atlantic City, N. J., from June 11 to 18, inclusive. The sessions will be held in the Greek Temple on the Million Dollar Pier and will extend from 9:30 a. m. to 12:30 p. m., except on Saturday, June 14, which will be available for the examination of exhibits.

On Wednesday, June 11, in addition to routine matters, there will be the annual address by the chairman of the Division, John Purcell, assistant to the vice-president of the Atchison, Topeka and Santa Fe; an address by President R. H. Aishton of the American Railway Association; and reports of the General Committee, the Committee on Nominations and the Committee on Locomotive Design and Construction.

On Thursday, June 12, there will be a discussion of the report on Shop and Engine Terminals and the following individual papers: The Modern Locomotive, by W. H. Winterrowd, assistant to president, Lima Locomotive Works; the Lehigh Valley Three-Cylinder Locomotive No. 5000, by J. G. Blunt, American Locomotive Company; the Relation of Track Stresses to Locomotive Design, by C. T. Ripley, chief mechanical engineer, A. T. & S. F.

On Friday, June 13, the reports on Locomotive and Car Lighting and Electric Rolling Stock will be discussed. An individual paper on Development of the Electric Locomotive, by F. H. Shepard, director of heavy traction, Westinghouse Electric & Manufacturing Company, will also be presented.

On Monday, June 16, Frank McManamy, of the Interstate Commerce Commission, will make an address and the following individual papers will be presented: Governmental Relations to Transportation, by W. R. Cole, president, Nashville, Chattanooga & St. Louis; Proper Training of Shop Supervisory Forces, by L. W. Baldwin, president, Missouri Pacific. There will also be discussions of the reports on Specifications and Tests for Materials and on Car Construction and the annual election of officers.

On Tuesday, June 17, there will be a discussion of the following reports: Prices for Labor and Material, Arbitration, Tank Cars, Loading Rules and Safety Appliances.

On Wednesday, June 18, the last day of the convention, the following reports will be discussed: Autogenous and Electric Welding, Brakes and Brake Equipment, and Wheels.

Some time during the sessions of the convention an address will be made by W. R. Scott, president of the Southern Pacific, Texas and Louisiana Lines.

The convention of Division VI, Purchases and Stores, of the American Railway Association, will also be in Atlantic City, June 16 to 18 inclusive.

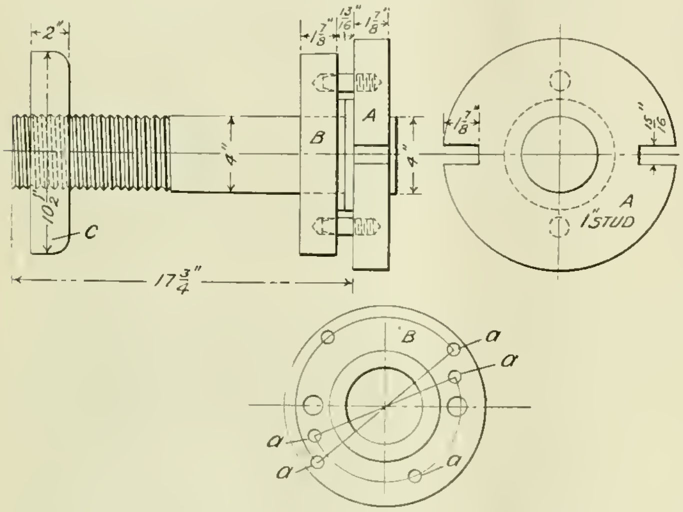
Shop Kinks

Some Handy Devices in Use on the Erie Railroad and the Chesapeake & Ohio Railroad

Chucks for Holding Hub Liners While Boring and Milling

Another handy tool developed in the same shop is a chuck for turning driving box brasses on a boring mill.

The base *A* consists of a disc at the bottom, 12 in. in diameter and 1⅞ in. thick. This is slotted on the edge to hold the face plate of the mill. From the center of this disc a heavy stud 4 in. in diameter rises to a height of 17¾ in. This is cut with a thread of 8 to the inch for a distance



Chuck for Turning Driving Box Brasses on Boring Mill

of 7 in. from the top and carries a disc nut *C* 10½ in. in diameter and 2 in. thick.

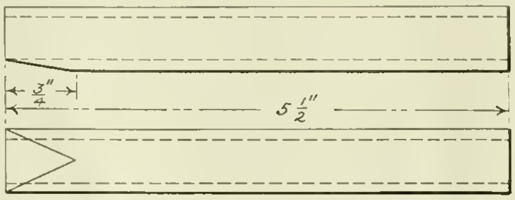
Another disc of the same diameter is slipped over the stud and rests upon two 1 in. dowel pins, which serve as drivers. This plate *B* is drilled and tapped at *A A* to receive ⅝ in. square head set screws that are 2½ in. long under the head. The nut *C* is also drilled in a similar manner.

These set screws serve to align and hold the brass in place.

The brass is set on the points of the set screws projecting up through the disc *B* and squared with the machine by them. The nut *C* is then run down on the thread and turned until its set screws come into line with those in the disc *B*. These set screws are then tightened to hold the brass in place and it is ready to be turned.

Device for Opening Cotters

This is a handy little tool for opening cotters and is made of a piece of ⅜ in. pipe 5½ in. long. At one end



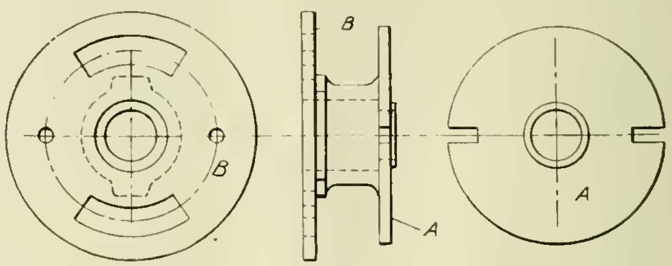
Device for Opening Cotters

the wall of the pipe is flattened and ground off chisel shaped on one side, and that is all. The sharp edge can, then, be inserted in the split of a cotter and the leg bent to one side. A reversal of the device, and the other leg can be bent, thus leaving the cotter in the desired open position.

Chucks for Holding Hub Liners While Boring and Trimming Outer Edges

This chuck was also developed at the Buffalo shops. It was made from an old cylinder head. The lower part has a flange which is 14 in. in diameter and ¾ in. thick. It has a boss 4 in. in diameter projecting from the bottom to fit the mill and is also slotted at the edges, to suit the same requirements.

The top flange *B* is made from the cylinder head proper



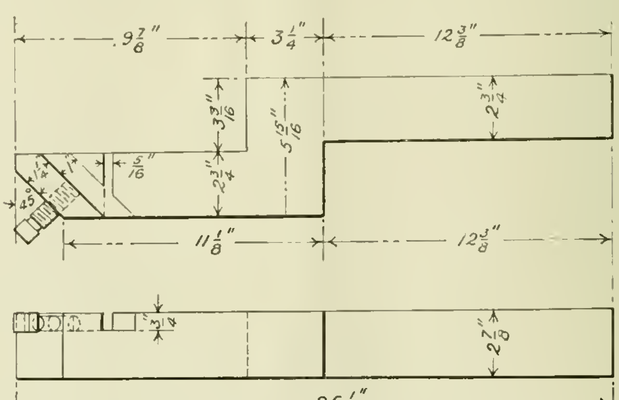
Chuck for Holding Hub Liner While Boring and Trimming Outer Edges

and is 16 in. in diameter and ¾ in. thick. This has two diametrically opposite slots, each 7⅜ in. long and 1⅞ in. wide, cut through it, as well as two ⅞ in. holes at right angles to the slots.

These are for the purpose of taking the holding down bolts which have counter sunk heads, that drop into the corresponding holes in the hub liner that is to be finished. This leaves the hole, the outer edge and upper face clear for the action of the cutting tool.

Chucks for Holding Cylinder Packing Rings While Cutting at Angle of 45 Degrees

This is a very simple arrangement, also found in the Buffalo shops, for holding packing rings while cutting the slot. It may be made of cast or wrought iron. It is made



Chuck for Holding Cylinder Packing Rings While Cutting at Angle of 45 Deg.

rather heavy so as to avoid any tendency to spring, under the cut.

There is a slot in the left hand section, 1 in. wide and ¾ in. deep into which the packing ring, to be cut is dropped and in which it is held by a ⅝ in. set screw.

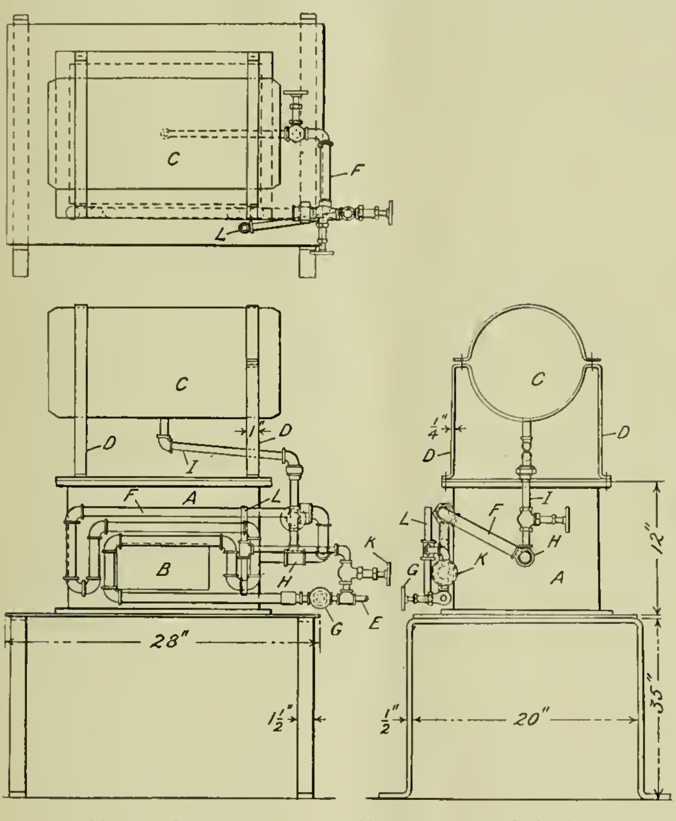
Directly in line with the outer edge of this slot there is another 5/16 in. wide and of the same depth for the passage of the cutting tool.

When the right hand arm is bolted to an angle or down on the bed of a shaper the chuck is set for cutting and the rings can be dropped into place, fastened and accurately cut with great rapidity. After the first adjustment has been made no setting of the cutting tool is required, as it will be in line with the slot, and has simply to be fed down into the work and again raised when the cutting has been completed.

Oil Burning Rivet Forge

The Cheasapeake & Ohio Ry. is using a number of small oil burning forges for heating rivets, similar to the one shown in the engraving.

Some of them are mounted on stationary tables as in the case of the one illustrated, and some are mounted on small-



Oil Burning Rivet Forge, Chesapeake & Ohio Ry.

wheeled trucks, so that they can be moved from place to place as the requirements of the work to be done may require.

The furnace is contained in a casing *A* which is lined with firebrick, and has an opening *B* for the insertion of the rivets. The oil tank *C* is carried by two saddles *D*. made of 1 in. by 1¼ in. flat steel and is 10 in. in diameter and 20 in. long.

The compressed air enters at *E* and is admitted to the coil of pipe *F* by the valve *G*. The air is thus circulating through this coil, which is laid in front of the furnace, is preheated before the atomizer at *H*.

Meanwhile the oil flows by gravity down through the pipe *I* to the atomizer where it is caught by the current of compressed air and is injected into the furnace.

The piping used is ½ in. for the air coil and ⅜ in. for the oil delivery. Rising from the inlet pipe and controlled by the valve *K*, there is a ⅜ in. pipe that turns and delivers air to the vertical pipe *L*. This pipe is perforated on the left hand side with a row of holes that discharge streams of air forming a curtain in front of the furnace opening. This serves the same purpose as a water table and cuts off the intense heat of radiation from the faces of the rivet heaters.

These furnaces are giving excellent results and are rapid and economical in operation.

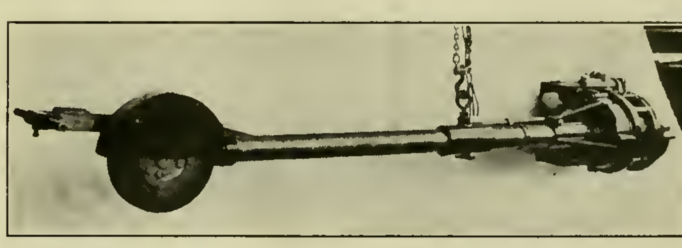
Motor Driven Swing Frame Grinder

The Diamond Machine Company of Providence, Rhode Island have placed on the market a direct connected motor driven swing frame grinding machine. The illustration shows the machine with the motor an integral part of it.

Two sizes are built for any current characteristics except 25 cycle in which case only one size may be obtained. For standard current one size has a 12 in by 2 in. grinding wheel, driven by 3 hp., 1800 r.p.m. motor the other has an 18 in. by 4 in. grinding wheel, driven by 5 hp. 1200 r.p.m. motor and for 25 cycle current the machine has 14 in. by 2 in. wheel with 3 hp. 1500 r.p.m. motor.

The old belt driven type were most inconvenient to use in foundry and railroad shops because of the high head room necessitating longer supports and belt centers. Such motor driven outfits as were available had the motor fastened in overhead frame work, thus requiring belts that limit the area that the grinder could cover.

Instead of these old type cumbersome ceiling supports,



Motor Driven Swing Frame Grinder

a Standard 8 ft. chain hoist holding the machine at its center of gravity is furnished. This feature allows the machine to be readily raised or lowered as the grinding may necessitate. This support is so nicely balanced that none of the operator's strength is taken in moving or swinging the machine This feature enables the machine to be hung from a hook in the ceiling or a light jib crane which could swing the grinder over a wide area.

The motor is carried on a special end piece rigidly fastened to the hollow arm in which the driving shaft revolves. At the wheel head end there is a set of nickel steel spiral bevel gears for driving the wheel. These gears are fully enclosed and are run in oil. The machine is ball bearing throughout. These bearings are of ample capacity, and are in dust proof housings.

One of the most important features of this machine is the easy accessability of the wheel, which can be removed by taking off side plate on Safety Guard and wheel flange. It is unnecessary to remove the spindle or expose the bearings, thus eliminating the possibility of getting dirt into them. For this reason the readjustment of bearings is not required which is in marked contrast to the frequent adjustments necessary in the older type of machine.

The ball bearings have a guaranteed life of five years. The gears are practically indestructible.

The wheel head swivels so that the wheel may be rotated 90° each side of the vertical position, independent of the rest of the machine. It can also be fastened at any angle.

The guard is built to meet the specifications of the American Engineering Standards Committee which specifications have been accepted as standard by Departments of Labor of many States and by leading industries.

The operator's handle is adjustable and can be fastened in any desired position from a horizontal position upward to a 45° angle.

Not the least interesting feature is the electrical control. The motor is operated by push button control attached to the operators handle within fingers' reach so that the machine may be started or stopped by the operator as he stands at his work position. The starter is fastened directly to the motor.

The machine is furnished ready to run, the only requirements are an overhead hook or eye bolt from which to suspend a flexible cable bringing the electric service to the desired location, connecting the power leads and pushing the button.

Snap Shots—By the Wanderer

It is often a matter of speculation with me as to whether all the efforts of the railroad companies to educate people to be careful and decent is not wasted. The country has been flooded with signs of safety first and cross crossings cautiously until it would seem as though the plea would be driven home to the consciousness of every traveler and every automobile driver in the land. Yet the grade crossing slaughtering goes on with an increasing ratio and the frantic race with the locomotive and death continues unabated. You may stand at any crossing any day and if you do not see some driver race to cross ahead of a train you will have happened there on an exceptional day.

It is scarcely a fortnight since I saw three drivers race in a bunch across a track in front of an approaching train, and the last one just was not hit and that is all. And this in face of a crossing watchman waving his lantern frantically to stop them. The least hitch in the steering or operation of any one of the cars would have wrecked the three of them. Fortunately the train was running slowly and so all escaped, little as they deserved to.

If they had been hit, I suppose they or their estate would have sued the railroad for damages, for the railroad is like the office boy, who did not know whether he was responsible or no, but did know that he was always to blame.

The way passengers and others will sue railroads for injuries resulting from their own misdeeds shows a deplorable lack of perception of what is right. Here are two examples to point the moral and adorn the tale.

First a woman enters a sleeping car with a child of four, and straighway turns the latter loose to go and come as he pleases. He wanders about, strays from one car to another and even tries to leave the train at a station stop. Twice the porter captures him and returns him to his not over anxious mamma, protesting that she ought to look after him or he will get hurt. The woman replies that she can do nothing with him. Finally, during the course of his wanderings the car lurches and the child is thrown against the arm rest of a seat and three teeth are knocked out, lips are cut and face bruised. After which the woman managed to keep the youngster with her. A passenger, opposite, by the way, remarked to her that he was sorry for the boy, but it served her right.

Of course, she sued the railroad company for damages and her husband even asked the porter to testify in her behalf.

There was to be a break-up of a train and a dining car was to be cut off. The gate on the dining car platform was closed, and the porter closed and locked that of the sleeping car next to it, and went off about other duties. A woman happened along, and opened both gates, pinching and cutting her finger on that of the dining car. She was about to step across to the dining car when the switcher pulled the car away. The porter happening on the platform at the moment caught her and saved her from falling between the cars. Then she sued the railroad company for the injury to her finger.

The Pullman Company have had a notice posted in the smoking and dressing rooms for two years or more, asking passengers to refrain from using the place for loitering or smoking until all have completed their toilet. The porters also post a notice in the evening, requesting quiet in consideration of persons who have retired. I have yet to go into the dressing room of a sleeping car in the morning when there were not one or more men calmly idling or smoking quite oblivious of the notice and of the fact that they were making a nuisance of themselves. And I have yet to be in a sleeping car when some man with a resonant, far-carrying voice that penetrated far into the car was not holding forth in utter disregard of the request for quiet.

Porters tell me that it is always so on every run, morning and night.

So, I ask, what's the use of trying to reform that mob of reckless inconsiderates whom are demagogic politicians are won't to denominate the clean public? Wouldn't it be quite as well to let them cripple and kill themselves, and harass their fellows, until the very mob rises against itself and puts a stop to the abuses?

While on this matter of safety, and having vented myself, it is worth while calling attention to a form of crossing gate that commends itself with a proviso that the reckless driver will regard it. It consists of half gates. That is gates extending half way across the roadway on the right hand side of the approaching side. If drivers will stay where they belong, on the right hand side of the road, a lowered gate blocks their progress. While if it is dropped behind them, after they have passed upon the tracks they are free to go on. This avoids getting caught between gates. The point arises, however, whether the reckless ones will not dodge over to the left hand side and try to zig-zag across the tracks after the gates have been lowered. You know there are many who seem to regard their time as worth about a million dollars a second as soon as they take hold of the steering wheel of an automobile.

I had occasion not long ago to hang around one of the round houses of a well-known railroad, night and day especially night for several weeks. And, by the way, there is nothing like hanging around to get at the true inwardness of things.

Well, one of the inwardnesses that I bumped up against rather strongly in this particular case, was the method of making running repairs. I must confess that there was nothing particularly novel about it, because I have seen it practiced not only elsewhere but almost everywhere, when I have had a chance to make a close observation and, as far as I can see, it is as old as railroading. It is a method or practice commonly known as robbing locomotives. The only difference being that, in this case it was particularly flagrant.

I would not be far out of the way to say that hardly a locomotive came in from a run that it was not straightway robbed of some attachment in order to make the "next out" engine ready. Injectors, oil cups, and lubricators seemed to be the favorites, but anything that could be removed while the engine was under steam was more than apt to go. While, if the engine was in for a washout, the robbing and stripping would be pretty complete.

It was simply the result of insufficient stores on hand. All hands—in the roundhouse—were agreed that it was expensive, and there was no end of grumbling over the extra work entailed. There was the removal and replacement of every piece stolen, which more than doubled the work called for. The saving that could be effected by the carrying of sufficient stores would pay someone a nice salary, so it seems to me, who am speaking as an observer, who does not know the whole inwardness. Yet I was told that the method had been in operation for years.

Speaking of roundhouse work, I ran across another way of doing work that did not seem to me to be the best in the world.

Engines in for backshop repairs were scheduled to be out on a certain day.

That schedule seemed to be so arranged as to make a record for quick work. Almost too quick, I thought.

The schedule was rarely over run, and when the appointed day arrived the engine was always run out of the shop—into the roundhouse. There, apparently, everything that could be done in the roundhouse was done. Grates and brick arches were put in place; ash pans were attached, the netting was put in the front end; rods were set up; the valves were set and all by men who belonged to the back shop forces and spent a good substantial portion of their time in going back and forth to the main shop or waiting for someone else to make the trip.

Why it would not have been better to have added a day to the schedule, and delivered the engine more quickly to the transportation department, in the end all ready for service is difficult to understand.

Roundhouse work alone by the backshop forces is always done at a disadvantage and at an increased expense above what it would have cost had they been busied within their own domain. So why take them out of it when it isn't necessary?

Possibly the habit of upper officers of asking for explanations of every seeming default may have something to do with it, for men don't like the making of excuses and explanations.

Notes on Domestic Railroads

Locomotives

The Seaboard Air Line is now inquiring for 10 Mountain type locomotives.

The Norfolk & Western Ry. has ordered 10 locomotive tenders from the American Locomotive Company.

The Cornwall Railroad has ordered one 4-4-0 type locomotive from the Baldwin Locomotive Works.

The Canadian National Rys. has ordered from the Canadian Locomotive Company 6 Mountain type locomotives and two large Vanderbilt tenders.

The Great Western Ry. has ordered one Decapod type locomotive from the Baldwin Locomotive Works.

The National Railways of Mexico have ordered from the Baldwin Locomotive Works 10 Mikado type locomotives, 22 Consolidation type locomotives, 8 narrow gage Consolidation type locomotives, 10 narrow gage 4-6-0 type locomotives and one gas-electric locomotive.

The Chesapeake & Ohio Railway has ordered 100 locomotives from the American Locomotive Company, 50-180 ton Mikados, with superheater equipment cylinders 28 by 32, and 50-157 ton Mikados with cylinders 28 by 30 with superheater equipment.

The Canadian National Railways has ordered 18 Mikado type locomotives from the Kingston Locomotive Company.

The Bikanes State Railways, India have ordered 5 Mikado type locomotives from the Baldwin Locomotive Works.

The Pacific Electric Ry will build 5 electric locomotives in its own shops it is reported.

The Cuba Railroad is inquiring for 4 Consolidation type locomotives.

The Canadian National Rys. have placed an order with the Kingston Locomotive Works for 5 Santa Fe type locomotives and is reported to be inquiring for 18 Mikado type locomotives.

Passenger Cars

The Northern Pacific Railway has placed an order for repairs to 5 dining cars with the Pullman Company.

The Florida East Coast Railway has ordered 3-70 ft. passenger coaches from the Pullman Company.

The Baltimore & Ohio Railroad is inquiring for 80 steel electric Motor cars for the Staten Island Rapid Transit Railway Company.

The Bessmer & Lake Erie Railroad has ordered 6 combination baggage and passenger cars, 3 combination baggage and mail cars and 3 baggage cars from the Pressed Steel Car Company.

The Atchison, Topeka & Santa Fe Railway has ordered 20 baggage cars from the Pullman Company.

The New York Central Railroad has ordered 50 all steel suburban coaches from the Osgood-Bradley Car Company.

The El Paso & Southwestern System has ordered 3 buffet baggage cars and one dining car from the American Car & Foundry Company.

The Detroit, Toledo & Ironton Railroad is inquiring for 3 coaches, 3 baggage-mail cars and 2 combination coaches.

The Nashville, Chattanooga & St. Louis Railroad has ordered 4 baggage cars from the American Car & Foundry Company and 3 coaches from the Pullman Company.

The St. Louis Southwestern Railway is inquiring for one gas electric motor car.

The Virginia & Rainy Lake Railway has ordered one motorized car from the Oneida Mfg. Company, Green Bay, Wisc.

The National Railways of Mexico are inquiring for 45 standard gauge and 40 narrow gauge passenger cars.

The Chesapeake & Ohio Railway has ordered 4 all-steel dining cars from the Pullman Company.

The Canadian National Railways has ordered 4 parlor-buffet observation cars and 6 parlor cars from the Canadian Car & Foundry Company.

The Richmond, Fredericksburg & Potomac Railway is inquiring for 3 express cars and 2 coaches.

The North Western of Brazil is inquiring for 3 first class coaches and 3 second class coaches.

The New York Central Railroad has ordered one diner from the Pullman Company.

The Caro Northern Railroad has ordered one railway motor car from the Edwards Railway Motor Car Co.

The Cape Fear Railways has ordered 50 passenger motor cars from the Edwards Railway Motor Car Co.

The New York, New Haven & Hartford Ry. is inquiring for 3 multi-unit passenger cars.

The Illinois Central Railroad is contemplating the purchase of 200 suburban cars in connection with the electrification of its suburban lines.

The Wabash Railway is inquiring for 20 passenger cars, as follows: 10 baggage cars, 5 chair cars, 2 diners, 3 passenger and baggage cars.

The Morrisey, Fernie & Michel Railway has ordered two railway motor cars from the Edwards Railway Motor Car Co.

The Florida East Coast Ry. is inquiring for 100 ballast cars.

The Swift & Company are inquiring for 100 steel underframes.

The Fruit Growers' Express is inquirnig for 1,000 underframes for cars, also 4,000 axles.

The Virginian Railway has ordered 100 caboose car underframes from the Virginia Bridge & Iron Co.

The Detroit Edison Company is inquiring for 12 all steel hopper cars of 50 tons' capacity.

The Wabash Ry. has ordered 200 center sill reinforcements from the Decatur Iron Works.

The Atlantic Fruit Company has ordered 8 dump cars from the Magor Car Company.

The American Smelting & Refining Co. is inquiring for 15 gondola cars, of 50 tons' capacity.

The Texas Gulf Sulphur Company is inquiring for 40 tank cars of 10,000 gal. capacity.

The Southern Pacific Co. has ordered 30 automatic air dump cars with the Case Crane & Engineering Co.

The Central Railway of Brazil is inquiring for 50 refrigerator cars also 80 cars of 22 tons' capacity.

The New York, Chicago & St. Louis Ry. is inquiring for 100 steel underframes for 40-ton box cars.

The Gary Tube Company has ordered 17-100 tons and 13-70 tons skelp cars from the Pressed Steel Car Company.

Freight Cars

The Central Vermont Ry. is inquiring for 12 steel underframes for caboose cars.

The Wabash Railway has ordered 200 center sill reinforcements from the Decatur Iron Works.

The Florida East Coast Railway has ordered 200 ventilated box cars and 20 caboose cars from the Mount Vernon Car & Manufacturing Co.

The American Radiator Company is inquiring for one flat car.

The Chicago, Rock Island & Pacific Railway is inquiring for repairs to 250 refrigerator cars.

The Delaware, Lackawanna & Western R. R. is inquiring for 40-8 wheel caboose cars.

The Phillips Petroleum Company has ordered 125 tank cars of 8,000 gal. capacity from the General American Tank Car Corporation.

The Pere Marquette Railway is inquiring for 34 underframes for caboose cars.

The Northern Pacific Co. is inquiring for 20 center sill reinforcements for caboose cars.

The Canadian Car & Foundry Co. and the Eastern Car Company have purchased the 47,000 tons of freight car materials which were originally intended for the Russian Imperial Government and which have been stored in Canada since the war.

The Carnegie Steel Company has ordered 30 all steel hopper cars of 70 tons' capacity from the Pressed Steel Car Company.

The Western Fruit Express Co. has ordered 1,000 underframes from the American Car & Foundry Co. They are also inquiring for 4,000 axles. The cars are to be built in their own shops.

The Chesapeake & Ohio Ry. is inquiring for 100 caboose cars.

The East Broad Top Railroad & Coal Company is inquiring for 50 steel hopper coal cars of 35 tons' capacity.

The Baltimore & Ohio Railroad is reported to be inquiring for 3,000 freight cars and also 5,000 gondola cars.

Building and Structures

The Central of Georgia Railway has awarded a contract for the construction of a coach and paint shop at Savannah, Ga., to cost approximately $350,000.

The Western Pacific Railroad has awarded a contract covering the construction of a roundhouse, repair shop, storehouse, etc., at Stockton, Calif.

The Missouri Pacific Railroad plans to rebuild its tin and machine shops at Fort Scott, Kans., which were recently destroyed by fire.

The Wabash Railway has commenced construction of a coach shop at Decatur, Ill., to replace one recently destroyed by fire.

The Reading Company has awarded a contract for the construction of a metal covered machine shop in its yard at St. Clair, Pa.

The Central of Georgia Ry. has awarded a contract covering the erection of a coach and paint shop at Savannah, Ga., to be one-story 210 by 300 ft. and to be constructed of concrete, brick and steel.

The Erie Railroad will build a wheel repair shop at Hornell, N. Y., to cost approximately $75,000.

The Pennsylvania Railroad has awarded a contract for a boiler house for the new Juniata shops at Altoona, Pa., to cost approximately $50,000.

The Atchison, Topeka & Santa Fe Ry. has awarded a contract for building unit four to its San Bernardino shops at San Bernardino, Calif., to cost approximately $200,000.

The Elgin, Joliet & Eastern Railroad is asking bids covering a new powerhouse at East Joliet, Ill.

The roundhouse and repair shops of the Western Maryland R. R. at Bowest, Md., were completely destroyed by fire recently, also two locomotives were destroyed.

The Seaboard Air Line Railroad plans the enlargement of its machine stops at Abbeyville, S. C.

The Detroit, Toledo & Ironton Railroad has purchased a large tract of land at South Charleston, Ohio, and it is reported that the railway plans to construct a terminal there including roundhouse car repair shops and other buildings.

The Reading Company has awarded a contract covering the furnishing and erection of an addition to its office building ol the motive power department.

The Southern Railway has awarded a contract covering the construction of a 37-stall roundhouse and flue shop at Spencer, N. C.

The Pennsylvania Railroad has awarded a general contract covering a one-story power house at its shops at Juniata, Pa., to cost approximately $50,000.

The Joplin Union Depot Co., has awarded a contract for a new roundhouse to replace the structure destroyed by fire.

The Grand Trunk Ry. will ask bids on a new engine house and locomotive repair shop at Battle Creek, Mich., estimated to cost $800,000.

The Wrightsville & Tennille Railroad plans the erection of new locomotive and car repair shops at Dublin, Ga., estimated to cost $90,000.

The Chicago, North Shore and Milwaukee Railroad has commenced work on the shops at Waukegan, Ill., which when completed will replace the present shops at Highwood, Ill.

The Long Island Railroad has awarded contracts to the Westinghouse Electric Co., covering equipment costing $700,000 for six new substations in connection with the electrification of a portion of its line.

The Southern Pacific Co. plans the following construction at Englewood Yards, Houston, Texas. A building 400 feet long for cars undergoing heavy repairs, a building 200 feet long for modern machinery to dress lumber used in car repairs, a shop with 3,200 square feet of floor space for preparing and assembling wheels and axles.

Items of Personal Interest

R. M. Brown, engineer of motive power of the New York Central Railroad with headquarters at New York has been appointed assistant superintendent of motive power with the same headquarters.

Fred C. Reinhard has been promoted to assistant general boiler inspector on the Santa Fe System with headquarters at La Junta, Colo., and **Joseph Vonderhaar** becomes assistant boiler shop foreman with headquarters at Fort Madison, Iowa.

C. G. Henderson has been appointed master mechanic of the Southern with headquarters at Charleston, S. C.

A. C. Rinker has been appointed superintendent of shops of the Great Northern Ry. with headquarters at Superior, Wisc., succeeding **M. J. Stoll**, retired.

R. H. Mallet has been promoted roundhouse foreman of the Santa Fe System with headquarters at Clovis, N. M. **O. C. Patrick** has been promoted to boiler shop foreman with headquarters at Phoenix, Ariz. **W. P. Hartman** has been promoted to assistant roundhouse foreman with headquarters at Raton, N. M., and **Fred Wire** has been promoted to assistant general car foreman with headquarters at Argentine, Kansas.

F. E. Russell, assistant mechanical engineer of the Southern Pacific Company with headquarters at San Francisco, Calif., has been promoted to mechanical engineer with the same headquarters succeeding **H. Stillman**, who has retired.

W. T. Cooper has been promoted to general foreman of the International Great Northern Ry. with headquarters at Mineola, Texas.

D.Wood, assistant mechanical engineer and assistant engineer of tests, of the Southern Pacific Company has been promoted to engineer of tests with headquarters at San Francisco, Calif.

M. D. Stewart, master mechanic of the Southern Railway with headquarters at Alexandria, Va., has been transferred to Spencer, N. C., succeeding **C. G. Goff**, who has been transferred to South Richmond, Va.

Walter D. Smith, superintendent of Oakland shops of the

Chicago & Eastern Illinois Railway at Danville, Ill., retired on May 1.

E. J. McLean has been promoted shop foreman of the Rock Island Lines with headquarters at Horton, Kansas, succeeding **H. S. Ferguson,** transferred to Caldwell, Kansas.

D. W. Cunningham, general master mechanic of the Missouri Pacific Railroad with headquarters at Little Rock, Ark., has been appointed master mechanic with headquarters at Jefferson City, Mo., succeeding **F. W. Gratiot,** the position of general master mechanic has been abolished.

Gilbert Bisson has been appointed master mechanic of the Copper Range Railroad with headquarters at Houghton, Mich.

John G. Treacy has been appointed general foreman of the Great Northern Ry. with headquarters at Devils Lake, N. D., succeeding **A. C. Rinker,** promoted.

J. L. Butler, has been appointed master mechanic of the Missouri Pacific Railroad with headquarters at Pupo, Ill., succeeding **E. R. Lockhart** who has been appointed traveling engineer of the White River division with headquarters at Crane, Mo.

Edward Clark has been appointed master mechanic of the Cornwall Railroad with headquarters at Lebannon, Pa., succeeding **John Wintersteen.**

Supply Trade Notes

The Vanadium Alloys Steel Company, Latrobe, Pa., has removed its New York office from 143 Liberty Street to 270 Madison Ave., New York City.

L. A. Marshall, service manager of the **Industrial Works,** Bay City, Mich., has been appointed sales engineer, with headquarters at Chicago, Ill., and **Fred J. Mershon,** export sales manager, has been placed in charge of the Detroit office with headquarters in the Book Building, Detroit, Mich.

D. S. Wood, district sales manager of the **Niles-Bement Pond Company** with headquarters at Philadelphia, Pa., has been transferred to Chicago succeeding **Samuel G. Eastman.**

L. S. Carroll, general purchasing agent of the **American Locomotive Company,** New York, has been elected vice-president in charge of purchases.

The Pressed Steel Car Company and the **Western Steel Car & Foundry Company** have moved their Chicago offices to Corn Exchange Bank Bldg., 134 So. LaSalle Street.

J. E. Otis, Jr., vice-president of the **Bassick Manufacturing Company** with headquarters at Chicago, has been promoted to vice-president and general manager succeeding **E. S. Fesler,** resigned.

The Chicago Bridge & Iron Works is planning an extension to its fabricating shop at Chicago, Ill.

Robert Huff, New York representative of the **McConway & Torley Company,** Pittsburgh, has removed his office from 2 Rector Street, to Room 1728, 30 Church Street.

Joseph T. Ryerson & Son, Incorporated, Chicago has taken over the exclusive distribution of Lewis special staybolt iron manufactured by the **Penn Iron & Steel Company,** Creighton, Pa.

The Ohio Injector Company is planning the construction of a three-story addition to its factory at Wadsworth, Ohio.

The Bucyrus Company, South Milwaukee, Wisc., is planning the construction of a new one-story addition to its tool room.

J. A. Turner, formerly purchasing agent of the Mobile & Ohio Railroad has been appointed representative of the **Fairmount Railway Motors, Inc.,** with headquarters in the Transportation Building, Washington, D. C. **L. R. Payton** has been appointed representative with headquarters in the Railway Exchange Bldg., St. Louis, Mo.

The Sullivan Machinery Company has moved its Pittsburgh office to the Farmers Bank Bldg., Rooms 517-520.

Frank E. McAllister, vice-president and general sales manager of the **Kalamazoo Railway Supply Company,** Kalamazoo, Mich., has been elected president and general manager to succeed the late **John McKinnon,** who died suddenly on April 5th. **Joseph E. Brown,** who has been a director of the company, has been elected vice-president. The other officers of the company remain the same.

Duncan W. Fraser, vice-president in charge of manufacturing and sales and **Joseph B. Ennis,** vice-president in charge of engineering of the **American Locomotive Company,** have been elected directors to fill vacancies.

The Garlock Packing Company has moved its Chicago sales office and warehouse to larger quarters in the Otis Elevator Company Bldg., at 600 West Jackson Blvd.

John B. Tinnon, until recently Engineer Maintenance of Way with the Chicago & Joliet Electric Railway, has been appointed to the position of Superintendent of Rail Welding with the **Metal & Thermit Corporation.** Mr. Tinnon is particularly well equipped for his new duties by reason of his many years of experience in track construction and track welding, having been connected with the Chicago City Railway as Assistant Engineer in charge of special work and track construction prior to his joining the Chicago & Joliet Electric Railway in 1912, as Engineer Maintenance of Way.

C. H. Smith, assistant secretary of the **Westinghouse Air Brake Company,** and director of clerical operations of all of that company's interests, has, in addition, been elected vice-president of the **Westinghouse Union Battery Co.,** of Swissvale, Pa. This is an important subsidiary of the Westinghouse Air Brake Co., producing the Westinghouse storage batteries for a variety of uses. Mr. Smith began his connection with the air brake company in 1900, in the correspondence and order department. In a few years he became head of the department and later was promoted to the position of assistant to the general manager. In 1916 he supervised important war contract work which the company carried on at Providence, R. I., and in 1917 was appointed assistant to the president of the Westinghouse Air Brake Co., and the Union Switch & Signal Co. He was made director of clerical operation of all air brake interests in 1919. Mr. Smith is a recognized authority on cost accounting and is prominent in the national councils of a number of business organizations, among them being the National Association of Cost Accountants, the National Association of Manufacturers, the National Tax Association and the National Association of Office Managers.

Arthur L. Pearson, assistant vice-president of the **Bradford Corporation,** with headquarters at Chicago, Ill., has been promoted to general manager with supervision over manufacturing operation and direct charge of the buying of materials and supplies.

The Samuel Smith & Son Co., Paterson, New Jersey, have organized for the manufacture of locomotive and marine boilers, steam boxes, etc.

George L. Bourne, president of the Superheater Co., has been elected a director of the **International Combustion Engineering Corporation,** New York, N. Y., succeeding **T. F. Fitzpatrick,** resigned.

The Buffalo Brake Beam Co. plans the erection of a new forge plant at Lackawanna, New York, as a part of its expansion program.

L. D. Albin, general sales manager of the **Ingersoll-Rand Co.,** New York, N. Y., has been elected vice-president in charge of Foreign Sales of that company. **D. C. Keefe,** assistant general sales manager, has been appointed to succeed Mr. Albin.

P. C. Pickard has been appointed works manager of the Erie plant of the **Standard Stoker Company,** at Erie, Pa. He recently resigned from the Delaware, Lackawanna & Western to become vice-president of the Talmage Manufacturing Company, which position he now leaves to enter the service of the Standard Stoker Company, Inc.

New Publications

Books, Bulletins, Catalogues, Etc.

Handbuch des Dampf-Locomotivbaues. (Handbook of Steam Locomotive Construction) by Dr. Martin Igel, professor at the Technical High School of Berlin, 606 pages, 5¾ in. by 8¼ in., 550 illustrations, M. Krayn, Berlin, Germany.

This handbook consists of a compilation of about everything pertaining to a locomotive, chiefly, though not entirely, German. It opens with a very brief review of the start of the railroad era in England with illustrations of the Puffing Billy and the Rocket followed by a few of the early German locomotives, and after a brief review of the types in use there is a chapter on the calculation of resistances. Here, as in most of the formulæ connected with other calculations, the author makes the mistake, so common to technical writers, of failing to indicate or specify the significance of the various symbols that he uses. The result is that unless the reader is perfectly familiar and quite sure of his familiarity with the author's nomenclature, the formulæ are quite useless.

Aside from these calculations, the book is filled with illustrations of all sorts of devices, and forms of locomotives and boilers, many of which are barely alluded to, with no pretence of a description as to construction or method of operation. For instance eight examples are given of firebox construction, in regard to which the descriptive text is scarcely an enlargement on the captions of the illustrations. To cite a definite case a half page illustration is given of a boiler with a firebox bearing a close resemblance to the siphon boiler. The text gives no information as to where or by whom it was designed and used, but merely states that "Fig. 42 shows two small triangular water chambers built vertically in the firebox. They run from the crownsheet at the top to the throat sheet at the bottom and support the brick arches. Because of the rapid circulation of the water through them, the deposition of scale is prevented." Further detailed information on the subject would certainly be desirable.

In some cases a more extended description is given, but the main dependence is upon the illustrations, and these, as has been said cover about everythnig connected with a locomotive. Fire boxes, oil burners, injectors, lubricators, mechanical stokers, without regard to successful operation or obsoleteness. This is strikingly shown in the case of the stoker, where out of four stokers illustrated only one is now being manufactured, and only two are in operation.

The last third of the book is taken up with brief descriptions of locomotives in use in all parts of the world. These descriptions give some dimensions but as there are hundreds of them there is no room for elaboration. At the end there are a series of tables in which is given a list of general dimensions of 540 locomotives running in all parts of the world. These dimensions, including the name of the builder and the year built, are those usually given.

Of course the book does not contain everything that there is, and unfortunately among the missing items are many that are well known while, among the included, are many now in the discard. So that while the book is a valuable one for reference, it is not one upon which the uninformed can place full reliance because it makes no distinction between current and obsolete practice, or success and failure.

The lack of an index is also very much to be regretted. But as a book of general reference it can be recommended in spite of its limitations and omissions.

U. S. Safety Appliances by H. S. Braughtain, assistant to Master Car Builder, Chicago, Milwaukee & St. Paul Railway: 246 pages: pockebook size. Published by the Simmons Boardman Publishing Company, 30 Church street, New York, N. Y. A practical manual of safety appliance laws, legal decisions and Interstate Commerce Commission orders and interpretations covering the application of safety appliances to the motive power and rolling stock of steam railways in the United States. The author, who has been engaged in railroad work for many years, early realized that railway employees were seriously handicapped by the difficulty of obtaining information as to safety appliance requirements. In his book on the subject the safety appliance acts and the orders of the Commission with their various amendments and interpretations, rulings, preferred practices, and the practices desired by the Commission are not only included, but are embodied at the actual point to which they have reference. Much practical experience in the field has been utilized in the preparation of this work, and it will be of great value to those railroad employees and to those who are concerned with the installation, operation and maintenance of safety appliances.

The Railway & Locomotive Historical Society has recently issued bulletin No. 7, another of the very valuable contribution to literature dealing with the early history of railways and locomotives issued under the supervision of the society. The issue before us contains the "Report of the Committee on Cars to the Direction of the South Carolina Canal & Railroad Co." submitted to the stockholders of that company in 1833. The illustrations of this section include reproductions of the original drawings of the locomotives "DeWitt Clinton," "Best Friend" and the "West Point." Another section deals with "Early Locomotive Building in Lowell, Mass.," prepared by Edwin R. Clark for the Lowell Historical Society. A list of the 32 early locomotives built by the Locks and Canals Company between 1835 and 1837 is given. The third chapter is devoted to "The Old Iron Horses of the Central Pacific" which includes several excellent illustrations of the period 1863-1867. Mr. C. Warren Anderson contributes an illustrated section devoted to the first railway and locomotives in Nova Scotia.

The bulletin is distributed to the membership, but those interested may purchase copies from Mr. Herbert Fisher, Box 426, Taunton, Mass.

Locomotive Feed Water Heaters: A new catalogue on Elesco Feed Water Heaters has just been issued by the Superheater Company of New York and Chicago. It describes construction details and fully illustrates the application of the closed or non-contact Heater to Locomotives. Of special interest are the four charts in colors at the center of the catalogue, illustrating the operation of Elesco Feed Water Heaters, and the Heat balance of Locomotives, with and without Feed Water Heaters. A careful study of these illustrations, with the aid of the description of them, will give a very thorough and practical understanding of how heaters save heat, fuel and water, by preheating feed water with exhaust steam, and how they operate. A variety of installations are also illustrated.

Car Heating & Lighting Combined Catalog and Instruction Book. The Gold Car Heating & Lighting Company have recently issued their catalog No. 24 describing their car heating and lighting apparatus, electric haters, ventilators and other railway supplies, together with instructions relative to the operation of them. Copies of the book may be had on application to the company, address, Bush Terminal, Brooklyn, N. Y.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XXXVII 114 Liberty Street, New York, July, 1924 No. 7

Two Unit Gasoline Motor Train

Maryland and Delaware Coast Railway Will Use Gasoline Operated Equipment in Freight and Passenger Service

There is a large amount of small unit transportation that can produce a good profit for the railroads, provided, they have the right equipment to handle it, but the user of this class of transportation seems to be going elsewhere for service as is indicated by the large number of bus and motor routes that are springing all over the country.

The expense of operation of the older equipment in such service is high and in many places the public is demanding something better than the old antiquated oil lighted coaches for passenger service.

To meet this competition the railroads have turned to gasoline motor cars and there has been a large increase in gasoline-operated equipment on steam railroads during the past year or two, such equipment replacing the two and three car steam passenger trains on non-paying branch lines, and in between local service on main lines.

Nearly all of the gasoline rail car developments have been for passenger service, but there is an equally good field for equipment of this character in freight traffic where the usual car is too large a unit for many conditions.

The recently incorporated Maryland and Delaware Coast Railroad are equipping their entire system with gasoline motor coaches and freight trucks. The first of these to be put in operation between Queenstown Md. and Lewes, Del., is a two-car all steel train consisting of a motor trailer which was built by the Four Wheel Drive Auto Co. of Clintonville, Wisconsin.

The motor car is 25 ft. 5½in. long from center to center of coupler, the length of the body overall being 21 ft. 7 in. The weight of the chassis complete is 11,000 lbs. Wheelbase 185 in.

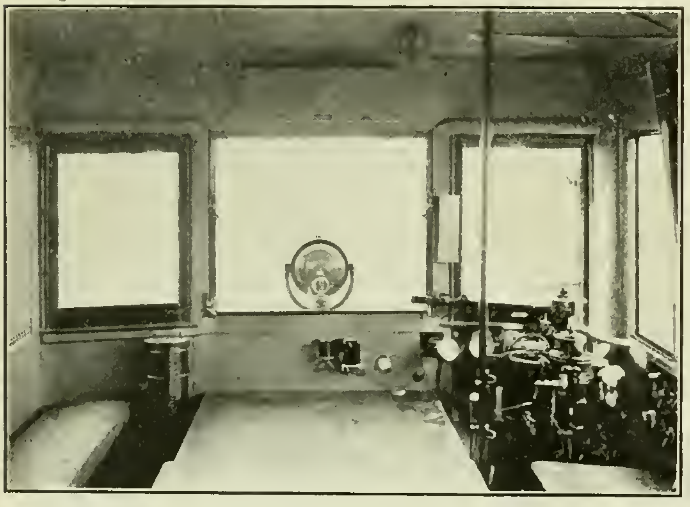
The six-cylinder 62 hp. motor has a bore of 5.1 ins. and a stroke of 5.5 ins., with a piston displacement of 672 cu. ins. The S. A. E. rating of this motor is 62 h. p., but it develops 94 hp. under brake test. The maximum draw bar pull is 3,780 lbs. obtainable with a gear ratio of 28.4 to 1 in low. The maximum speed with this gear ratio is 5.3 miles an hour and the draw bar pull of 3,780 lbs. is obtainable at two-thirds of the maximum speed, or about 3.5 miles an hour. With a gear ratio of 15.6 to 1 in low, a draw bar pull of 2,000 lbs. is obtainable at about 10 miles an hour. At the highest gear ratio of 3.9 to 1 in high a maximum speed of 40 miles an hour is obtained. The maximum draw bar pull obtainable with this gear ratio at 40 miles an hour is 500 lbs. These figures for draw bar pull are the maximum obtainable and a working safety factor of 20 per cent must be allowed from these figures. The transmission, which is of the jaw clutch type with gears always in mesh, has four speeds forward and as many in reverse. The reverse gear mechanism is mounted on a sub-transmission. This reverse mechanism contains a differential and per-

Gasoline Motor Train on the Maryland & Delaware Coast Railway mits the power to be transmitted to the car in either a forward or backward direction. The mechanism is controlled by a hand lever near the driver similar to the reverse lever of a locomotive. This mechanism permits the use of all four speeds of the transmission in either a forward or backward direction. It is mounted on ball bearings throughout and is housed in an oil-tight, dust-tight case and runs in an oil bath. It is also a jaw type construction, the gears always being in mesh.

Power is transmitted from the reverse gear differential to the axles through propeller shafts, each containing universal joints. These are of a superior type having hardened steel bushings running upon hardened steel pins and are thoroughly housed to make them dust-proof and oil-tight.

Both front and rear axles are rigid like the rear axle on a truck and are of the full floating type. Each axle contains a differential through which the power is transmitted to each driving wheel. These axle differentials in driving mechanism are completely housed in oil-tight, dust-proof housings and run in an oil bath. The weight of the car is taken upon these housings and not upon the driving axle.

The springs are 54 inches long, 2½ inches wide and



Interior View of Gasoline Motor Train Showing Driving Mechanism

made of chrome silicon manganese steel heat treated, four of the springs being used on the chassis. These springs are connected to the chassis frame with double spring shackles which allow the chassis to swing slightly sidewise, thus cushioning the side impacts against the rail and improving the riding qualities of the car. The action of these shackles is very similar to that of the swinging bolster used in railroad cars. The axles are held in place and alignment by radius rods. By the adjustment of these radius rods the wheels can be brought into perfect alignment.

The wheels are of cast steel hollow spoked type, the tires are of rolled steel with MCB contour, 35-inch diameter and are mounted same as a demountable solid rubber tire.

Cast iron shoe brakes are used on all four wheels, there being one brake shoe for each wheel. A Westinghouse Air Brake System is provided to operate these brake shoes and to provide air a Westinghouse air compressor is installed at the rear of the transmission. This air compressor is of 10 cu. ft. per minute capacity and is controlled by an automatic governor. An air strainer is provided at the intake of this compressor. This brake system provides all necessary safety valves, emergency valves, operator's valve, application valves and the like, to make it up to date and a reliable system. It is a two-pipe system similar to that used on street cars having a direct air system for service applications and an indirect system for emergency.

A sand box is placed at the rear of each rear wheel and at the front of each front wheel. The flow of sand from these boxes is governed by an air valve at the driver's seat. Air is provided for the operation of these sanders by the air brake system.

Standard MCB couplers are installed both at the front and the rear of the chassis. The front coupler has a re-inforced wooden filler block and is bolted rigidly to the front of the chassis frame. The rear coupler is of the spring type.

2-unit starting and lighting system is furnished consisting of a starting motor which operates on the fly wheel of the engine through a Bendix drive. A 270 Watt generator and a 225 ampere hour storage battery. The voltage of this system is 12 volts. Connections are provided for head light, sufficient body lights, driver's instrument light and rear marker lights.

With the chassis is provided in the exhaust line a valve by which the exhaust gases can be shunt through heating pipes in the car body.

The weight of the trailer complete is 6,300 lbs. the wheel-base 185 in., and the length from center to center of coupler 27 ft. 5 in.

Railroad Taxes in 1923 Were $37,906 Hour

Federal and State taxes paid in 1923 by the Class 1 railroads, excluding the large switching and terminal companies, averaged $909,747 daily, or $37,906 an hour, according to the Bureau of Railway Economics, basing its findings on reports just filed by the carriers. The total amount of taxes paid during the year was $332,057,588.

There has been a steady increase in the taxes paid by the railroads during the last thirteen years. The amount paid annually, as well as the average per day, follows:

Fiscal Year	Amount (In millions)	Amount per day
1911	$98,626	$270,211
1912	109,445	299,031
1913	118,386	324,348
1914	135,572	371,432
1915	133,276	365,141
1916	145,517	397,588
*1916	157,113	429,272
1917	213,920	586,082
1918	223,175	611,439
1919	232,601	637,264
1920	272,061	743,337
1921	275,875	755,825
1922	301,034	824,753
1923	332,057	909,747

*Fiscal year changed in 1916 to end on December 31 instead of June 30.

International Railway Meeting in Berlin

A railway convention of international scope is announced to be held in Berlin, Germany, from September 22 to 27, 1924, by the Society of German engineers. An exhibit of locomotives, rolling stock and appliances will be held in connection with the meeting. Lectures by German and foreign specialists on a variety of subjects, and discussions by the delegates will also be a feature. These lectures will include reports on turbine and internal combustion locomotives, air brakes, electrification, etc.

Report of Proceedings of the Convention of the Mechanical Division of the American Railway Association

The American Railways Association, Mechanical Division, which embraces the former American Railway Master Mechanics' and Master Car Builders' Associations, resumed its annual meetings at Atlantic City June 11 to 18 inclusive. The usual exhibits by the Railway Supply Manufacturers' Associations members occupied the entire Million Dollar pier, together with a new building across the boardwalk which housed several of the heavier exhibits. The exhibition by the manufacturers of railway appliances at the convention was the largest ever brought together for a similar purpose.

The chairman of the general committee for the 1924 meetings was John Purcell, Assistant to Vice President, Atchison Topeka & Santa Fe Ry., and the Vice Chairman J. J. Tatum, Superintendent, Car Department, Baltimore & Ohio R. R. J. Coleman, General Superintendent, Car Equipment, Central Region, Canadian National; C. H. Temple, Chief of Motive Power and Rolling Stock, Canadian Pacific, and L. K. Sillcox, General Superintendent of Motive Power, Chicago, Milwaukee & St. Paul, were also members of the general committee.

The principal reports of the committees and the individual papers are given either in full or in abstract on this and the following pages.

Engineering and Business Considerations of the Steam Locomotive

By W. H. Winterrowd, Assistant to President, Lima Locomotive Works

During the past few years, almost periodically, the press has presented to its readers statements conducive to the belief that the modern steam locomotive, if vital, is rapidly losing its vitality. The uninformed reader is left with the impression that the modern steam locomotive is inefficient, that it has reached a stage of development where further improvement can not be offered, and that a point has been reached where it can not meet practically and economically the traffic conditions of today.

Nothing could be farther from fact. The vitality of the steam locomotive is not on the wane. It is increasing. Development has not stopped. It is still in progress. The possibilities of increased efficiency and capacity guarantee a continuing progress. The remarkable development that the steam locomotive has undergone during the past twenty years is indicated by a comparison of the extreme figures for 1904 and 1923, which show that, with a 91 per cent increase in weight, there was a gain of 236 per cent in indicated horsepower, the improvement is approximately 48 per cent.

During the same period there was a very remarkable gain in thermal efficiency, or in the "efficiency of the fuel from coal to driving wheel contact with the rail."

Again, the maximum thermal efficiency increased from 5.22 per cent to 8.1 per cent or an increase of approximately one-half.

The importance of this development in conjunction with all the signs that point to much greater improvement have not been properly evaluated by those who urge a substitute for the modern steam locomotive; nor has proper consideration been given to the fact that it is possible to increase the capacity of the less modern locomotives and at the same time raise their efficiency to a point approaching that of the modern unit.

Any study of a substitute must include a consideration of not what the steam locomotive has done in the past but what is doing now and what it will do in the future If comparisons are made, the economies obtainable with the most modern form of locomotive should be used, otherwise the conclusions will be misleading.

A study of the data relating to the increase in capacity and efficiency of the steam locomotive, is of value because it affords an indication of the direction that future development is likely to take.

The accomplished increase in weight and capacity with its corresponding decrease in weight per indicated horse power is the joint result of increase in size and efficiency refinements. At the present time, physical limitations have been approached to such an extent that any future increase in capacity due to size will not be at the same rate as in the past. As a result, the greatest development of the future may be expected to take place in improvement of the locomotive as an efficient power plant. The particular direction that this development may take is best indicated by considering the locomotive boiler and engines separately.

Thermal Efficiency of the Locomotive Boiler

Steam locomotive boilers have been said to be wasteful and inefficient. A glance at the curves in Fig. 1 disposes of such statements. These curves establish the commanding fact that the locomotive boiler without having reached its limit is a more efficient generator of steam than the boiler in present-day stationary plants of maximum refinement and that its heating surface is a far greater producer.

In Fig. 1 the curves are plotted to show the combined efficiency of boiler, superheater and furnace at various ratings of normal boiler capacity and at varying rates of evaporation for both locomotive and stationary boilers. The curves No. 1, No. 2 and No. 3 are for modern locomotive boilers on engines in freight and passenger service. Curves No. 4, No. 5 and No. 6 are for modern stationary boilers in very large power plants representing the highest development of the art. It is important to note that the maximum capacity of these stationary boilers lies below the average capacity for these locomotive boilers. A comparison of these capacities takes on added significance, when it is remembered that the natural draft stationary plant greatly exceeds in cost, and space occupied, the forced draft locomotive plant.

Curves to be made in the future will be still higher in the case of the locomotive when equipped for tests with Type E superheater and feed water heater. Maximum combined efficiency closely approaching 90 per cent is in sight The marked gain made possible by the use of the Type E superheaetr indicates the very great possibilities of future gain due to the use of high temperature steam.

It may not be amiss at this point to make mention of a fact that does not seem to be fully recognized. As boilers have increased in size, the steam space above the water level has decreased, with the result that under operating conditions more and more moisture has been carried over into the superheater with the steam. The superheater has therefore been serving the double purpose of an evaporator and a temperature increaser. That the superheater has evaporated this moisture and in addition has increased the temperature of the steam, coincident with increasing boiler efficiency and capacity entitles it to a maximum of credit. This indicates, however, that if moisture can be removed from the steam before it reaches the superheater, that device can function 100 per cent as a superheater and do still more to increase the capacity and efficiency of the boiler. Steam separators are useful in this connection.

It is also consistent to emphasize the fact that the use of superheated steam in all the locomotive auxiliaries will increase boiler capacity in the sense that it will decrease the demand for steam.

It is well known that in a locomotive boiler, the greatest amount of water per pound of coal is evaporated when combustion occurs at a low rate in pounds of coal burned per square foot of grate area per hour. This fact is responsible for the growing tendency to use large grates. To take full advantage of this fact will require a grate area that will be responsible for some increase in weight. It also necessitates the use of a mechanical stoker, adding still more weight. But the effects of the increased weight can be neutralized by the use of a four-wheel trailer truck.

Tests made by the American Railway Engineering Association's Special Committee on Stresses in Railroad Track show that the use of a four wheel trailer truck will eliminate the concentrated load which placed at too great a distance behind the driving wheels is responsible for exceedingly high rail stresses. Trailer loads can be distributed and rail stresses reduced to such an extent that the increased weight will not be a factor in establishing limits of design.

It may be suggested that the use of large grate areas will considerably increase locomotive standby fuel losses and increase the amount of fuel burned when the engine is worked light. The increasing tendency to keep locomotives in continuous service with a minimum of standing time and the economic necessity for giving each locomotive its maximum load will offset this. In fact, this type of construction will lend itself to more continuous service for several reasons. In the first place, there will be less necessity to take the locomotive out of service for boiler and firebox maintenance, because the decreased rates of combustion will result in less severe firebox punishment. This construction will also lend itself to better ash pan conditions. The relatively large space made available by this type of truck will result in large ash pans that will provide sufficient capacity to carry the locomotive over more than one division, thus cutting down time at divisional points.

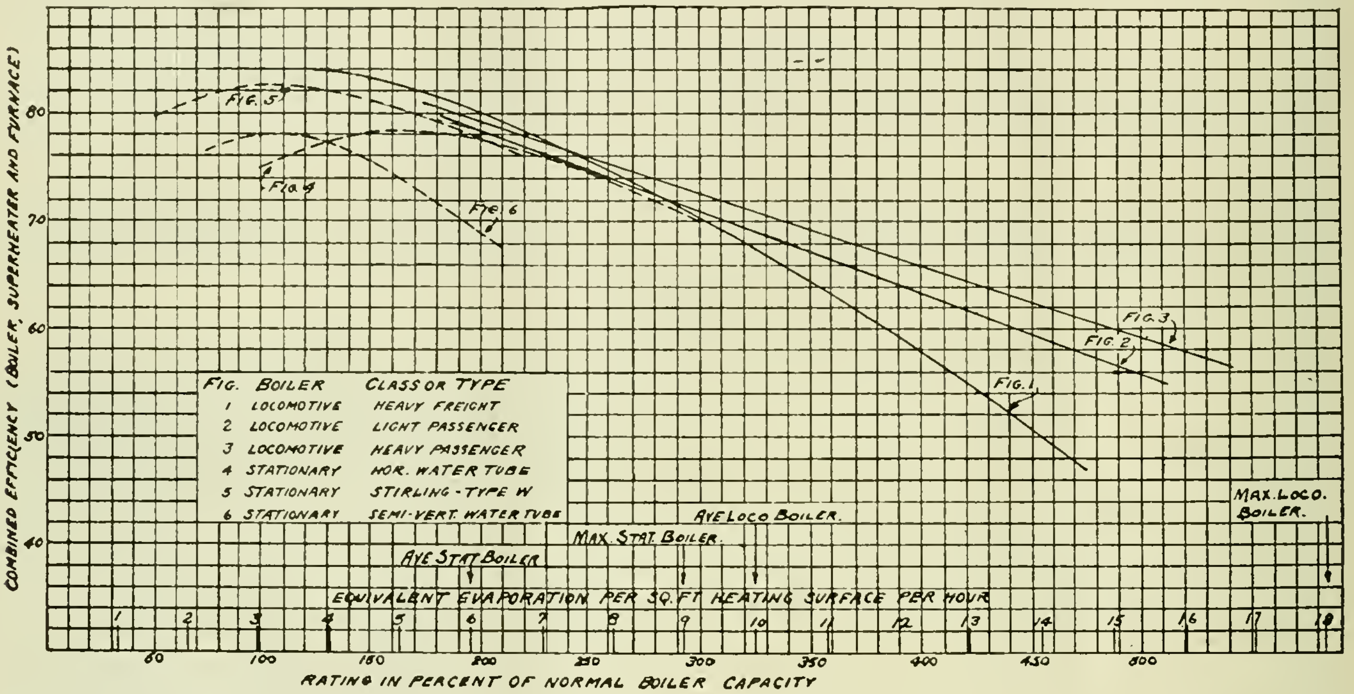


Fig. 1.—Curves Showing the Combined Efficiency of Boiler, Superheater and Furnace for Both Locomotive and Stationary Boilers

Another field for increased thermal efficiency is the use of steam at pressures considerably higher than those prevailing today. At the present time, high steam pressures are being given a great deal of consideration in both locomotive and stationary fields. It is being considered in the locomotive field, first, because large increases in pressure can be accomplished with the addition of a comparatively small number of heat units per pound of steam, and second, because advantage can be taken of high steam pressure to use the steam expansively.

Locomotive Design and Performance

To utilize the high pressure steam expansively and with maximum efficiency leads to a consideration of engine design and performance. The boiler must also be considered but chiefly in the sense that type, design, construction, weight and probable maintenance will be the principal factors in the determination of the practical limit of high pressure.

Efficient utilization of high pressure steam is a matter of using the steam expansively. In the most modern stationary plants, this is generally done by expanding superheated steam continuously through many stages in a single turbine, or by expanding it down to a comparatively low pressure in a high pressure turbine, re-heating the steam and then expanding it still further in a low pressure turbine. In both methods, condensers make it possible to obtain a maximum amount of energy from the steam.

To date, United States locomotive practice has not involved the use of the turbine. In Europe, several turbine locomotives are in service. These are condensing types with turbines and driving wheels connected by reducing gears. While the turbine locomotive offers rather alluring possibilities, its use in the very large units necessary in United States practice involves a satisfactory solution of the following problem, which should be given very careful consideration by any one considering this type of locomotive. In the first place it involves the matter of steam condensation. This involves numerous problems in itself. In the next place, the maximum efficiency of the turbine is limited to a comparatively small range of its speed. Still another problem is the matter of reversing. Finally, the turbine locomotives that have been constructed to date are of comparatively heavy weight for the horsepower developed.

Up to the present time, the efforts in the locomotive field of this country have been confined to the expansive use of high pressure steam in cylinders. So far, actual construction has confined itself to two methods. In one case, the locomotive is of the cross compound type and steam is used expansively, first in a high and then in a low pressure cylinder. In the other case, the locomotive is of the simple type with valve motion so designed that identical limited cut off in each cylinder insures expansive use of the steam. In the latter case the increased pressure insures the required mean effective pressure in the cylinders and the limited cut off results in an expansive use of the steam which means increased fuel economy.

A locomotive of the first type has just been constructed and will go into service shortly. The boiler is of the firetube type with a water tube firebox and carries 350 lb. steam pressure.

More than 600 locomotives of the second type have been constructed and are in service. These locomotives are equipped with standard locomotive boilers carrying 250 lb. steam pressure. It is on locomotives of this type that the highest efficiencies have been achieved. Moreover, they have been obtained with a maximum of simplicity and uniformity of turning torque. On these engines dry coal rates of less than 2 lb. per i. hp. hr. have been obtained. The minimum rate as less than 1.75 lb.

Some constructional advantages resulting from the use of high pressure steam lie in the fact that cylinder diameters can be decreased, the weight of reciprocating parts somewhat reduced, and within certain limits, boiler weights can be reduced. The use of steam pressures higher than those just mentioned is not improbable and developments in this direction will be watched with a great deal of interest.

A number of other possibilities exist that may eventually serve to increase locomotive efficiency still further. From time to time, efforts have been made to reduce or eliminate cylinder back pressure by methods other than those involving condensation of the steam. Some of these have involved the use of mechanical draft. The possibilities of increased efficiency and capacity make this an attractive field. The elimination of back pressure by condensing methods has been given a great deal of consideration but so far, no solution of the problem has been offered that appears entirely practical to deal with the quantities of steam involved in the really big locomotive of today.

It is also important to mention the very great value of a properly designed valve gear with adequate valve travel in reducing back pressure and improving cylinder performance.

A reduction of internal friction affords additional possibilities for increased efficiency and capacity.

In an effort to take advantage of its high thermal efficiency, serious thought is being given to the applicability of the internal combustion motor to the railway motive power field. There is not yet in sight a solution to the practical problems that surround the application of this type of power to make it meet the special and exacting requirements of the large units necessary for economical operation in this country.

As an example of one method used to increase locomotive capacity and efficiency by modifications within the unit itself, the three-cylinder simple locomotives put into service recently are of interest. The uniform turning torque made possible by the use of three cylinders is responsible for increased tractive force while the increased number of cylinder exhausts make a more uniform smoke vacuum resulting in improved combustion conditions.

As an outstanding indication of what can be done in the way of increasing locomotive capacity, chiefly by coordinated design and with but a very slight increase in size and weight, attention is directed to the diagrams and curves in Figs. 2 and 3. In Fig. 2, locomotive B represents a design that is fairly modern. Traffic grew and conditions changed to such an extent that the railroad concluded it would be profitable to operate locomotives of greater capacity but which must not exceed certain weight and size restrictions. Locomotive A was the result. A comparison of engine weights is as follows:

	Locomotive B	Locomotive A
Weight on engine truck, lb..	27,500	29,000
Weight on drivers, lb........	245,000	248,000
Weight on trailer, lb.........	49,500	58,000
Total weight, lb...........	322,000	335,000

It will be seen that the greatest increase in weight was made on the trailing wheels due to the application of a booster. Additional weight on engine truck and drivers is comparatively small.

The speed-pull curves in Fig. 3 show the very great increase in capacity of locomotive A over locomotive B. With but slightly more than a one per cent. increase in weight on drivers, and a total increase in engine weight of but approximately four per cent, the majority of which was due to the application of a booster on the trailing wheels, starting tractive effort was increased 20,000 lb. or 39 per cent., and at speeds over 18 m. p. h. tractive effort was increased between ten and eleven thousand pounds. At 20 m. p. h., this is an increase of practically 28 per cent. At 30 miles, it is an increase of 47.8 per cent, while at 40 m. p. h. it is an increase of approximately 78 per cent. This increase from 28 per cent to 78 per cent means decreasing the time between terminals with a heavier load. It shortens the railroad.

On the basis of this increased capacity the operating officer possesses motive power units, three of which will accomplish the work previously done by four; and this with a locomotive burning no more coal than its predecessor and not exceeding by more than four per cent the weight of locomotives now generally considered up-to-date.

Such motive power, co-ordinated to produce results like these, is an investment that places in the hands of the operating officers a means to revolutionize his operating figures. Its value in money can hardly be estimated.

Consideration of all the foregoing relative to the rapid development of the steam locomotive might lead to the conclusion that in the past the locomotive has rapidly reached is limit of usefulness on account of obsolescence. In many cases, economic conditions have made this true.

In the majority of cases, it has not been true for the reason that additions and betterments to the locomotives themselves have increased their efficiency and capacity and greatly prolonged their useful life. These fuel saving factors and capacity increasers have been instrumental in preserving a very large original investment, and in making possible a much greater return on that investment. There are still a great many locomotives in service that can be made useful units in economic railway operation by the addition of these factors.

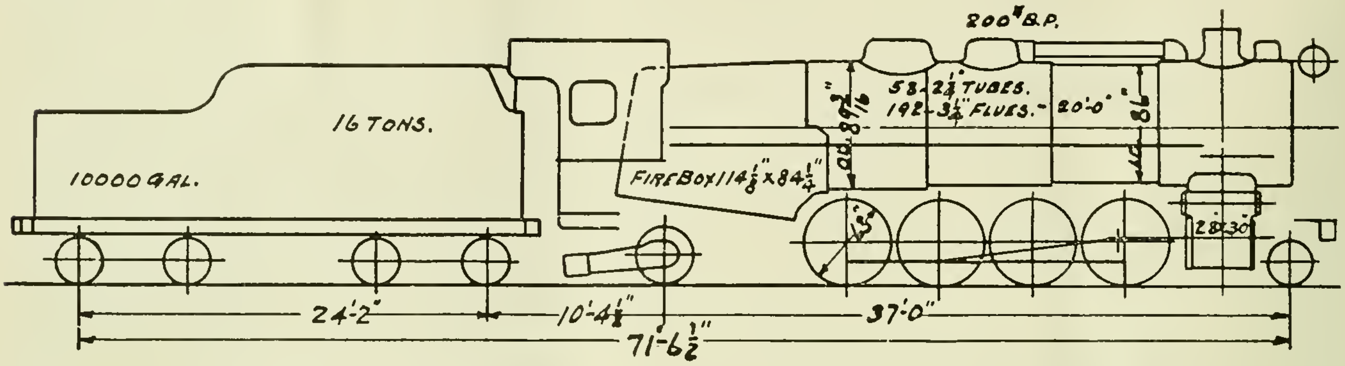


Fig. 2.—Locomotive A, Application of Booster Increased Its Tractive Force 28 Per Cent to 78 Per Cent Depending on Its Rate of Speed

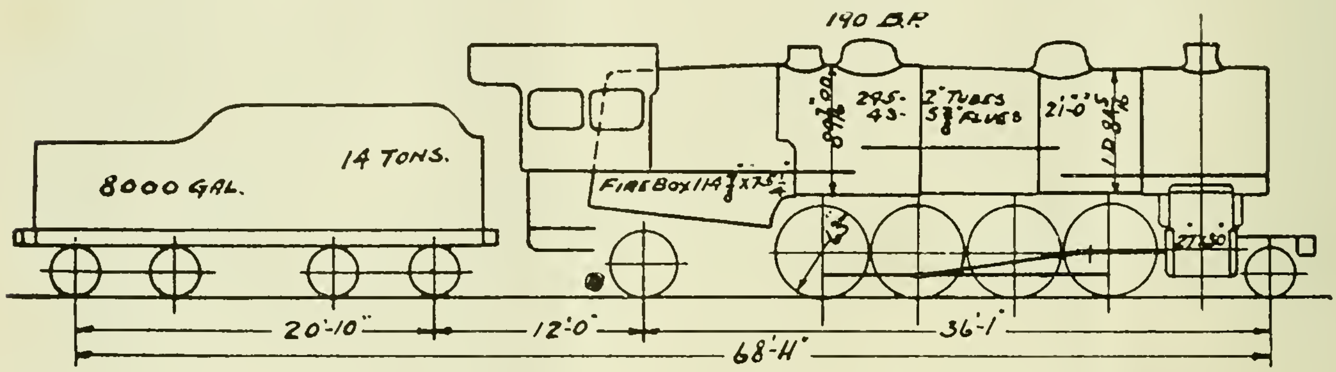


Fig. 2.—Locomotive B, Showing General Dimensions of a Fairly Modern Locomotive Not Equipped With a Booster

The Locomotive as an Economic Unit

The very great and rapid growth of transportation as well as the radically changing conditions contemporaneous with that growth have resulted in conditions that make it a business necessity for every railway to have constant and accurate knowledge of the economic value of its motive power. Without that knowledge, it is not possible to operate motive power to maximum advantage nor to make it earn the greatest possible return on the investment.

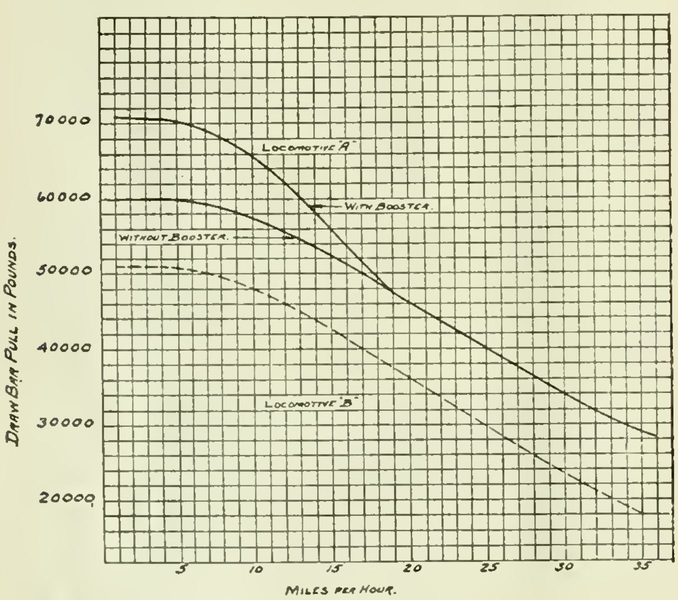


Fig. 3.—Speed Pull Curves of Locomotives A and B

To obtain such a comprehensive view of motive power requires an analysis involving vital factors. It involves not only a consideration of the physical characteristics of the property but a consideration of the nature of the business both present and future, the most advantageous assignment and operation of motive power, the character and condition of the equipment, labor conditions, and a knowledge of how to consider these and other factors in the light of a business investment. A sound consideration of motive power as an investment in turn involves a reliable knowledge of the latest development in the art of locomotive construction and operation.

This is a matter of very great importance and it is the opinion of the writer that this Division of the American Railway Association can render exceedingly helpful service by assisting to establish a definite method of analysis that will at all times insure a proper economic consideration of this question.

The thought has been expressed that increased efficiency and capacity are purchased at the expense of locomotive simplicity, and increase in maintenance costs. This is true but can the results be attained in any other way? The history of the development of motive power of all kinds indicates that it can not. The so-called complications are absolutely essential to increased efficiency and capacity and must be considered in the broad business sense that they greatly increase the economic value of the locomotive, so much so in fact that the additional cost of maintenance is a small item in the greater returns made possible with the improved unit.

In connection with maintenance, the writer feels constrained to draw attention to the fact that for any economic consideration of the subject, maintenance cost based on the locomotive mile unit is not a reliable criterion.

Exceedingly important factors in the cost of running and shop repairs are the size and capacity of the locomotive and the rate and amount of work that it actually performs. The mileage basis eliminates these factors.

Considered on the mileage basis, the maintenance of the so-called modern locomotive will exceed that of the old locomotive. But if the improvements are factors that result in substantially increased capacity, the locomotive will do more work than its old sister and the additional maintenance will be more than offset by the increased earning capacity of the unit. The best basis for a consideration of maintenance costs in their proper economic light is one that will involve capacity as well as the rate and amount of work performed by the locomotive. Such for instance would be a tractive effort-ton mile-hour basis.

The locomotive must be considered as an economic unit. In fact, is there any reason why each locomotive should not be treated as a separate unit and treated as a public utility corporation would treat each of its power plants? The original cost of the locomotive is known, the carrying charges are capable of determination, and the yearly cost of operation can and should be determined against the work performed in the way that good business demands.

The writer can not close without some reference to the type of publicity that has been given from time to time to some of the various proposed substitutes for the modern steam locomotive. Railroad men can not afford to deceive themselves regarding substitutes; neither should the public deceive itself. A substitute for the steam locomotive of the past is demanded not only by the exacting conditions of the present but by the still more exacting conditions inevitable in the future. The natural, sensible, and logical substitute is the steam locomotive itself, improved in accordance with the knowledge, experience and vision that is now available.

The Three-Cylinder Locomotive

By Mr. J. G. Blunt, Mechanical Engineer, American Locomotive Company

The demand for a greater tractive power, without increasing axle loads, has been a problem constantly presented to the locomotive builder, and I shall endeavor, in the remarks which follow, to show the advantages expected to meet this requirement by the use of the 3-cylinder principles in locomotive construction versus the 2-cylinder locomotive, each using single expansion steam. The 3-cylinder principle is by no means new, it having been employed to a considerable extent in England, Germany, Sweden and other European countries, where it is now operating successfully. In the United States, a few locomotives have been built in the past using the 3-cylinder principle, but in nearly every case abandoned.

Starting heavy trains, ascending grades, as well as in the maintenance of maximum speeds, the locomotive is required to exert its maximum effort and this effort is obtained when the tractive power line fluctuates a minimum amount above and below the normal (or straight) tractive power line. This normal line is approached in direct proportion to the number of cylinder impulses per revolution of the driving wheel.

It is well known that car and locomotive journals at rest are more difficult to start than to keep in motion. A 3-cylinder locomotive, with greater ability to start a train from rest, and by reason of its similar ability after starting, enables the engineer to throw the engine after starting quickly into a shorter cutoff position than with the 2-cylinder locomotive. Therefore, the 3-cylinder locomotive delivers its tractive power with steam used more expansively than in the case of the 2-cylinder locomotive, resulting in a more economical use of steam and a correspondingly less fuel consumption. We have, therefore, the means for obtaining in a steam locomotive the greatest tractive power for the least weight and accompanied by an unmistakable fuel economy.

The 3-cylinder locomotive being more economical in the use of steam and fuel, there follows a lesser boiler requirement, this condition being further improved by the more even draft on the fire resulting from the three exhausts per revolution of the driving wheel, which in turn permits the use of a relatively larger exhaust tip, with less back pressure.

The reasoning follows that the total weights of the 3-cylinder locomotive may be kept very closely within those of the 2-cylinder engine having equal axle loads, and still deliver a marked increase in tractive power.

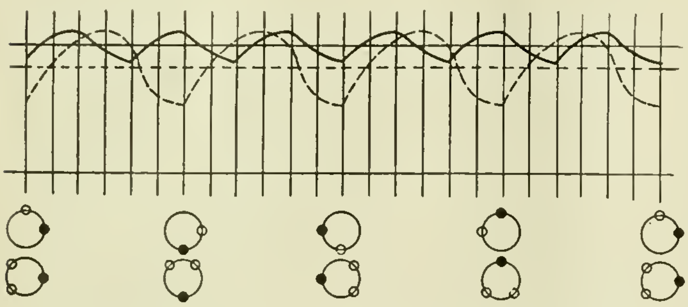
Each of the three cylinders is smaller than either of those in a 2-cylinder locomotive and the reciprocating weights being balanced independently (the middle balance being applied to the crank axle discs and for each outside cylinder in the driving wheel), produces a less dynamic effect on the track of approximately 30 per cent, so that in a 2-cylinder locomotive, while the dynamic effect may produce a maximum of 50 per cent over the static load at wheel speed (this speed being the equivalent in miles per hour of the number of inches diameter of the driving wheel), there would be only 35 per cent in the case of the 3-cylinder locomotive.

A locomotive of the 3-cylinder type, reconstructed from a 2-cylinder locomotive by the American Locomotive Company, and operating over a period of nearly two years, has shown a hauling capacity 50 per cent in excess of its performance prior to reconstruction, at the same time showing a fuel economy of from 10 per cent to 16 per cent.

It follows further that the 3-cylinder locomotive, by virtue of its lighter reciprocating parts and correspondingly less dynamic effect, should run faster. Confirming this assumption, a run was recently made with a 3-cylinder engine manufactured by the American Locomotive Company at approximately 12 per cent above wheel speed, showing remarkable absence of vibration or nosing effects, this absence of vibration and nosing effect resulting from the combination of the 3-cylinder principle with accurate leading and trailing truck resistances.

The above reasoning offers a solution for a larger steam locomotive unit without enlarging or increasing the right of way, bridges or other structures, thereby providing means for moving a greater tonnage over an existing line, or moving the same tonnage over a line with a less number of locomotives.

I have previously stated that a few 3-cylinder locomotives were built in this country and later abandoned. Many have felt, and not without apparent reason, that the 3-cylinder principle has been tried out time and again and proved a failure, therefore it would be useless to bring up the question again. I wish, in view of this apparently logical conclusion, to say that the abandonment of the valuable features which a 3 cylinder locomotive offers, is undoubtedly due to deficient and unreliable construction of those parts strictly involved in the 3-cylinder application. If the 3-cylinder locomotive is to be a success, we must, of course, see that these features are at least as reliable and as easily maintained as similar parts in the 2-cylinder locomotive; in other words, the great possibilities and utility of the 3-cylinder locomotive have heretofore been given up, due to failure in mastering the details of construction. While these failures have attended past trials of the 3-cylinder principle, indications are that the 3-cylinder locomotive has the constructive features well in hand bidding fair to fill a much needed place in railroad transportation.



Full Line, Three Cylinder Locomotive. Dotted Line, Two Cylinder Locomotive. Full Horizontal Line, Mean Tractive Power, Three Cylinder Locomotive. Dotted Horizontal Line, Mean Tractive Power, Two Cylinder Locomotive.

It is said we have been working for years to get all working parts outside where they can be easily gotten at and now the 3-cylinder locomotive is proposed, bringing the old troubles back. All I can say is, when the Walschaert and other outside valve gears superseded the old Stevenson motion, no increase in tractive power and none of the advantages above outlined were offered. With this third cylinder added, we offer increased power, speed and economy to offset the parts added by the third cylinder, and I feel sure that mature reflection will throw the balance infinitely in favor of the 3-cylinder principle.

There is a real problem before us of the increased weight of parts, whether caused by the addition of devices to effect economies, those to meet other increasing demands, or increasing the weight of parts under stress for security against failure. These, as you are aware, have practically reached the limit and employing the 3-cylinder principle seems to be a very practical way to meet these demands.

Autogenous Welding

An article was published in Railway and Locomotive Engineering for January, 1924, descriptive of certain tests that had been made as to the effect of autogenous welding in the building up of the flanges of steel tires. The result of this investigation tended to show that the practice is not a safe one to follow.

The committee on autogenous welding that made its report in June conducted its investigation on the steel of axles and wheels that would fall under the classification of medium high carbon steel.

It was found that in building up tires as represented by Plate A, there was a difference in the physical properties as represented by the various zones of welding metal. The hardest zone being produced under application of the filler metal while the base material was relatively cold, acting thereby as a more severe quenching medium against the zone heated by the arc of welding than in such cases where the tire had been to some extent preheated by the previous heat of welding. In this case the maximum increase in hardness and strength of the base material due to the transformation of the structure by the welding was approximately 40 per cent, and the hardness of the applied low carbon metal was approximately 55 per cent of the original hardness of the tire material.

The structural transformation of tires by gas welding, Plate B, showed, in this case, a reversed condition, inasmuch as the heat imparted to the base material has a slower penetration than the electric arc and instead of increasing the hardness and strength in the transformed zones, the physical properties were lowered as a result of annealing by the slow application of the heat.

The two light shaded semicircles in this etching, represent a first and second heat made during the application of the filler metal, the maximum decrease in the physical properties of the base material in this case amounting to approximately 24 per cent. The hardness of the filler metal itself is approximately the same for the Gas and the Electric welds, but the gas weld shows distinct decarburized zones forming the junction between the applied filler metal and the base material.

Rolled Steel Wheels. Similar conditions as found in tire steel exist for rolled steel wheels as shown by Plate C, representing a weld made by the gas method. The top view of this plate shows the condition of the steel after welding not followed by annealing, the lower view representing the same weld after annealing.

A typical service failure of a tire due to local heating produced by welding, is that of a tire which was applied without shims and was practically new at the time of failure, which occurred with four detail fractures starting from the retaining shoulder. It developed that through

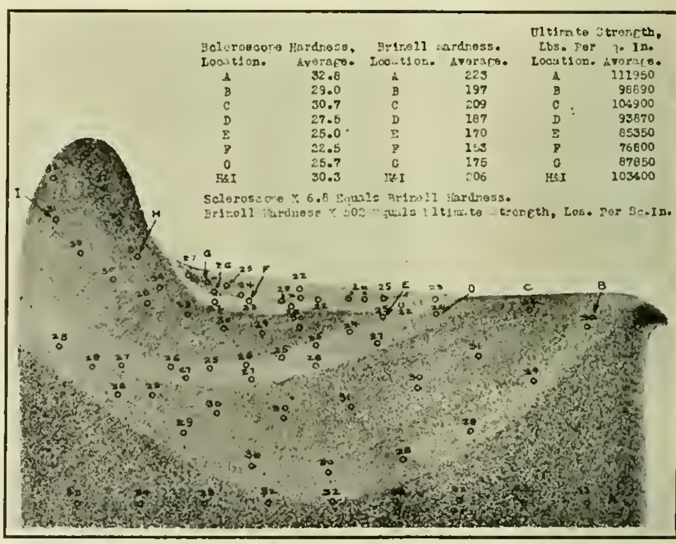


Plate A—Transverse Section Through Locomotive Tire, Welding of Flat Spots by Electric Process

some error on the part of the shops, the retaining shoulder had been turned off, and in order to save the tire, four short sections of retaining shoulder at quadrant locations, were built up by means of the electric welding process. The tire was not annealed subsequent to welding. The four (4) fractures, all developing from the built up sections, afford positive evidence that the high internal stresses produced by the welding were the direct cause of the failure.

In accordance with this investigation welding of steel and steel tired wheels will invariably cause a distinct local change in structure with resultant internal stresses, unless the material is properly preheated and annealed after weld-

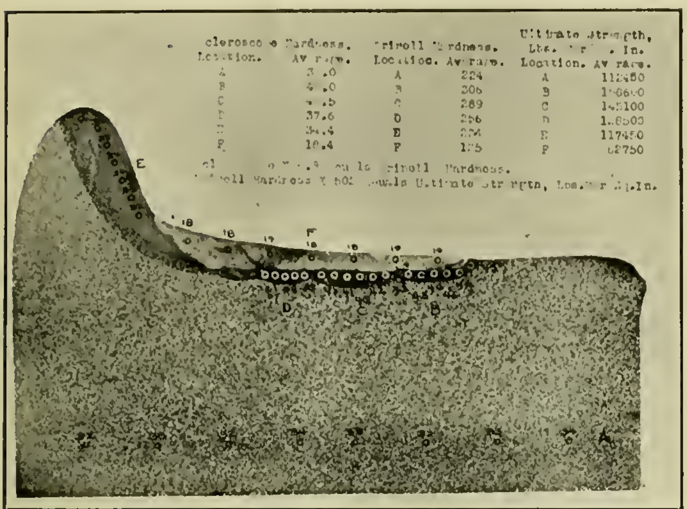


Plate B—Transverse Section Through Locomotive Tire, Welding of Flat Spots by Gas Process

ing. It has to be further considered that the applied filler metal, either carbon or alloy steel has, in most cases, different hardness and physical characteristics than the base

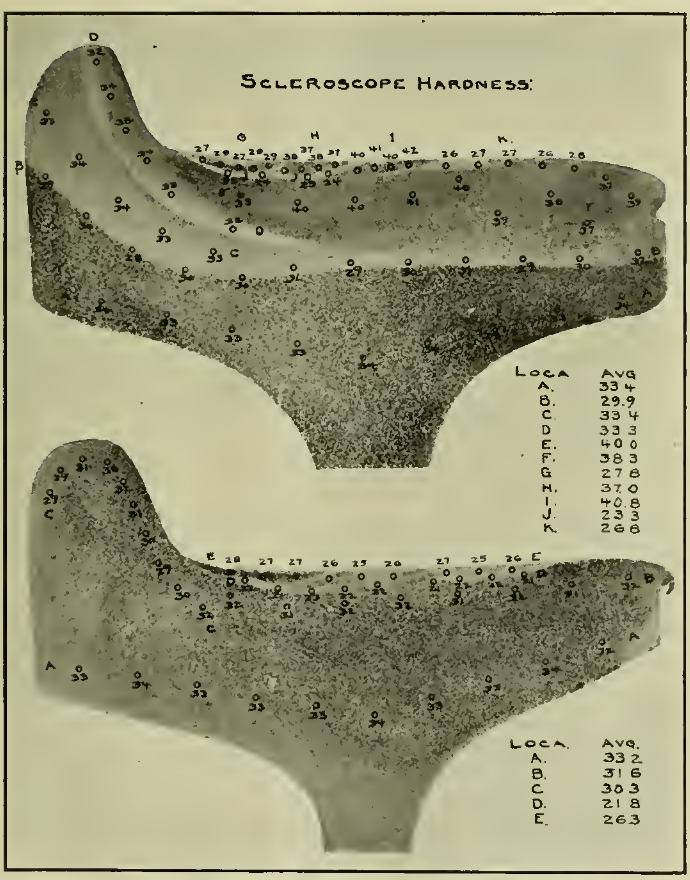


Plate C—Transverse Section Through the Rim of a Rolled Steel Wheel With Flat Spots Welded by the Gas Method. Top, Before Annealing; Bottom, After Annealing

material; moreover, with the gas welding process a pronounced decarburized area is formed between the base material and the filler metal and for this type of welding it is very probable that the filled in areas will readily slouch out by parting along the decarburized zone. Against this the electric weld has the pronounced disadvantage that unless a rather deep penetration of the heat is obtained, with consequent increase of internal stresses, the filler metal will not adhere properly. There is no doubt that if welding of this kind would be permitted, rulings as to proper preheating and annealing, would in a large number of cases be disregarded, and wheels and tires in a state of high internal stresses would be placed in service, with the result that failures directly due to the welding would occur.

A similar condition of structural transformation due to the welding heat exists on axles where the carbon ranges above 0.30 per cent.

The transformation in structure with corresponding internal stresses at points in an axle where bending stresses of any magnitude occur, will readily permit development

Plate G—Service Failure of Railroad Motor Car Axle Through Inside Fillet of Journal, Built Up by the Electric Welding Method

of detail fractures, and welds can, therefore, not be permitted on any part of the axle, with exception of the building up of end collars where practically no bending stresses exist. Such welding may be done without preheating or annealing by the electric welding method. The gas method is not recommended unless it is controlled so as to avoid the possibility of excessive heating during welding; which may, if not properly controlled, cause the transformation of the structure at the point where bending stresses occur.

Plate G represents the service failure of a railroad motor car axle on which the inner fillet of the journal bearing had been rebuilt by the electric process. The fractured face showed a distinct progressive failure starting from the zone of applied filler metal. The longitudinal etching shows the pronounced structure transformed which caused internal stresses, evidently, the direct cause of development of rupture. The pronounced structural transformation indicates that the axle was not preheated or annealed after welding.

Couplers: Numerous experiments were made to determine the physical characteristics of welded cast steel on rectangular specimens approximately ¾ inch in thickness. All specimens were annealed and the reinforcement removed prior to testing. The following average results represent the physical properties of welds on which, upon examination of the tensile fracture, the welding was considered as a good mechanical job.

	Lb. per Square Inch Yield Point	Ult. Strength	Elongation in 2" Across Weld—%
Electric Welding Method	32,500	47,000	5
Gas Welding	34,000	52,000	12
Original Material	35,000	70,000	27

The quality of the gas welds could still further be improved by the use of alloy welding wire, such as nickel steel. However, in all cases, although the welds were made by experienced operators, the physical properties obtained were of wide variation, which necessitates a margin of safety, which can only be obtained by proper reinforcing of the weld. Inasmuch as such reinforcement on coupler parts would interfere with the proper operation, the ruling that welding of coupler bodies, etc., be prohibited should be sustained.

Low Carbon Steel: On low carbon steel the transformation of structure due to the welding heat is not very severe. The general rule, however, applies that on account of the more gradual applied heat by the gas welding method, the transformation in structure is less abrupt and the internal stresses imparted to the material are, therefore, not as severe as those obtained by the electric welding method. Moreover the fusion obtained by the gas welding method is better and the filler metal shows less slag and oxide inclusion than the filler metal applied by the electric welding process.

Wrought Iron: On wrought iron, on account of the negligible carbon content, no local change of the parent metal can be noticed, and annealing after welding is not necessary.

Cast Iron: All cast iron parts, except cast iron wheels, may be welded. The gas welding method should be used wherever possible. One hundred per cent welds, without reinforcement, can be readily obtained by proper preheating and cooling of the material, using cast iron welding sticks.

Cast Iron Wheels: Welding of flat spots on cast iron wheels produces a similar condition as is found on welded wrought steel wheels and tires. The welding heat causes a distinct change in structure of the material adjacent to the weld. Moreover, such welding, on account of the relatively high internal stresses, which exist in all chilled cast iron wheels, could only be done by careful preheating of the wheel followed by uniform cooling, inasmuch as any locally applied heat would readily cause cracks through the chilled area similar to the cracks produced by excessive brake-shoe action, or even entire rupture of the wheel. The filler material itself would be very much softer than the chilled portion of the wheel, and a filled in area would offer very little resistance to wear. It is very doubtful that cast iron wheels would be properly preheated and cooled when welded, which would cause wheels in a state of highly unbalanced stresses, to be placed in service. We, therefore, recommend that any welding on cast iron wheels be prohibited.

Non-Ferrous Metal: Non-ferrous metals may be welded by either the gas or electric welding method, but as a rule the gas welding method is preferable.

Torch Cutting: Torch cutting has a similar effect on the material as gas or electric welding. On low carbon steels, approximately 0.25 per cent carbon maximum, the transformation is relatively small and can be disregarded. On steels above 0.25 per cent carbon, however, this method of cutting should only be used when the transformed zone, which increases in depth with the increase in thickness of material, can be either removed by machining, or is reduced by annealing subsequent to cutting.

In general, it may be stated that welding or heat cutting will impart internal stresses to the base material which are in approximate direct ratio to the carbon content and in inverse ratio to the original temperature of the base material. These stresses are produced by the local transformation of structure, which is caused by heating the surface metal to a temperature above the recalescence point and the underlying cold base metal acting as a quenching medium.

The committee, therefore, recommended that in addition to the prohibitions already in force the welding of cracks or fractures will not be permitted on air reservoirs—main, brake levers, crank pins, draw bars and safety bars, grab irons, rods—main, side, piston, valve and all forgings in rod shape, constituting valve motion work; steps or step straps, of wrought iron or wrought steel.

The Committee then gave a list of the places where welding was permissible, including the boiler. But here we find very strict limitations imposed, and it is prohibited in the crown-sheet or the side sheets within 12 in. of the crown.

Brakes and Brake Equipment

Owing to the high coefficient of friction developed by some brakeshoes at Purdue University, during the past year, the question has arisen as to whether the maximum as well as the minimum should not be provided for in the specifications.

The report then calls attention to the desirability of paying more attention to brake beam hangers and the method of attaching them to the trucks. It points out that no satisfactory 12-in. brake cylinder equipment for 6-wheeled freight trucks has yet been designed and closes with a recommendation that a force of 125 lbs. applied at the rim of the brake wheel or 3 in. from outer end of hand brake ratchet lever will develop an equivalent load "W" at the brake cylinder piston of not less than 2,500 lb. and 3,950 lb., respectively, for cars having 8-in. and 10-in. cylinders.

Tractive Power for Mallet Locomotives, Locomotive Design and Construction

The feature of this report lays not in the report itself, but in Exhibit A attached thereto, which gave the formulæ that have been developed for the calculation of the tractive power of Mallet locomotives. This exhibit states that the formula now in general use for the simple locomotive gives only an approximation of the actual tractive power of such a locomotive, because simple locomotives vary in maximum cut-off, back pressure, internal friction, etc. For the same reasons, any formula adopted for determining the tractive power of Mallet locomotives will give only an approximation of the actual tractive power. However, the same reasons that justify the adoption of a universal formula for the tractive power of the simple locomotive, also justify the adoption of a universal formula for the tractive power of the Mallet locomotive.

There are two general types of Mallet locomotives:

1st, the four cylinder simple,
2nd, the four cylinder compound.

The following symbols apply to all formulæ given:

C = Diameter of high pressure or simple cylinder in inches.

	Tractive Power	Simple or Compound	Approximate Maximum Cut-Off Percent	Cylinder Ratio	Authority
I	$T = \frac{1.7\ P\ C^2\ S}{D}$	Simple	90	....	A. R. A.
II	$T = \frac{1.5\ P\ C^2\ S}{D}$	Simple	50	....	
III	$T = \frac{1.7\ P\ c^2\ S}{\left(\frac{c^2}{C^2}+1\right) D}$	Compound	90	All	
IV	$T = \frac{1.5\ P\ c^2\ S}{\left(\frac{c^2}{C^2}+1\right) D}$	Compound	50	All	
V	$T = \frac{1.2\ P\ C^2\ S}{D}$	Compound	90	2.35-2.40	Baldwin Loco. Works
VI	$T = \frac{1.7\ P\ c^2\ S}{(R+1)\ D}$	Compound	90	All	Baldwin Loco. Works
VII	$T = \frac{K\ P\ c^2\ S}{D}$	Compound	90	(*)	American Loco. Co.
VIII	$T = \frac{1.6\ P\ c^2\ S}{(R+1)\ D}$	Compound	90	All	G. R. Henderson Loco. Operation
IX	$T = \frac{1.7\ P\ C^2\ S}{D}$	Simple	90	....	Interstate Commerce Commission (**)
X	$T = \frac{1.5\ P\ C^2\ S}{D}$	Simple	50	....	
XI	$T = \frac{1.7\ P\ c^2\ S}{\left(\frac{c^2}{C^2}+1\right) D}$	Compound	90	All	
XII	$T = \frac{1.5\ P\ c^2\ S}{\left(\frac{c^2}{C^2}+1\right) D}$	Compound	50	All	

Exhibit A—Formulae Developed for the Calculation of Tractive Power of Mallet Locomotives

c = Diameter of low pressure cylinder in inches.
S = Stroke in inches.
P = Boiler pressure in pounds per square inch
D = Diameter of driving wheels in inches.
H = Mean effective pressure of high pressure or simple cylinder in pounds per square inch.
E = Mean effective pressure of low pressure cylinder in pounds per square inch.
R = Ratio of cylinder volumes = $\frac{c^2}{C^2}$
M = Constant = .85 for 90 per cent cut-off locomotives.
= .75 for 50 per cent cut-off locomotives with .75 per cent cut-off auxiliary ports.
Q = PM = Total mean effective pressure in cylinders in pounds per square inch.
T = Tractive power in pounds.

Of the values of "M" given above, the first has been generally adopted for simple locomotives having approximately 90 per cent cut-off. The second value, that for locomotives having approximately 50 per cent cut-off, is taken from results obtained from the Pennsylvania class Ils (2-10-0) locomotives. In these locomotives, each piston valve bushing has an auxiliary steam port ⅛ in. long by 1¾ in. wide and having ¼ in. steam lap. These auxiliary ports or some similar devices are necessary for the successful operation of the 50 per cent cut-off locomotive. The constant .75 is recommended for all locomotives having approximately 50 per cent cut-off and means for supplying auxiliary steam to a cut-off of at least .75 per cent.

The four cylinder simple Mallet is essentially nothing more than two simple locomotives with but one boiler. Therefore, the tractive power of this type of locomotive is double that of the simple locomotive, or

$$T = \frac{2\ M\ P\ C^2\ S}{D}$$

which becomes— $T = \frac{1.7\ P\ C^2\ S}{D}$ for 90 per cent maximum cut-off locomotives, and

$T = \frac{1.5\ P\ C^2\ S}{D}$ for 50 per cent maximum cut-off locomotives.

The four cylinder compound is usually equipped with a device by means of which the locomotive can be operated as a simple locomotive at certain times. Under this condition the tractive power of the locomotive would be

$$T = \frac{(H\ C^2 + E\ c^2)\ S}{D}$$

In a properly designed compound locomotive, it is the intent that the piston pressures will be equal. If they are not equal, one pair of cylinders will do more work than the other pair which would not be economical. Therefore, we may assume that the mean effective pressures vary inversely as the squares of the cylinder diameters, or

$$\frac{H}{E} = \frac{c^2}{C^2} = R \qquad (1)$$

Now the sum of the mean effective pressures of the high and low pressure cylinders will be equal to the total mean effective pressure or

$$H + E = Q \qquad (2)$$

Substituting value of H from formula (2) in formula (1), we have

$$\frac{Q - E}{E} = R \qquad (3)$$

From which

$$E = \frac{Q}{R + 1} \qquad (4)$$

The tractive power of the low pressure cylinder is

$$T = \frac{E c^2 S}{D} \qquad (5)$$

Substituting value of E from formula (4) in formula (5), he have

$$T = \frac{Q c^2 S}{(R + 1) D} \qquad (6)$$

Since we have assumed equal power for the high and low pressure cylinders, the tractive power of both pairs of cylinders is double that of the low pressure cylinder, or

$$T = \frac{2 Q c^2 S}{(R + 1) D} \text{ which becomes:} \qquad (7)$$

$$T = \frac{1.7 P c^2 S}{\left(\frac{c^2}{C^2} + 1\right) D}$$ for locomotives with approximately 90 per cent maximum cut-off, and

$$T = \frac{1.5 P c^2 S}{\left(\frac{c^2}{C^2} + 1\right) D}$$ for locomotives with approximately 50 per cent maximum cut-off.

For comparison, the above formulæ are given in the following table, all formulæ given being for four-cylinder locomotives.

TABLE No. 1—CONSTANTS ("K")

Per Cent Cut-off H. P. Cylinder	Ratio of L. P. to H. P. Cylinder Volume						
	2.2	2.3	2.4	2.5	2.6	2.7	2.8
90........	....	....	.571	.557	.542	.528	513
89........	....	....	.565	.550	.536	.521	.507
88........	......	.573	.559	.543	.529	.515	500
87........	....	.567	.552	.537	.523	.509	.494
86........	.575	.560	.546	.531	.517	.502	489
85........	.570	.555	.540	.526	.511	.497	.483
84........	.564	.550	.534	.520	.506	.491	....
83........	.559	.544	.529	.515	.500	.486	....
82........	.553	.541	.524	.510	.496	....	....
81........	.548	.534	.520	.505	.490	....	....
80........	.543	531	.515	.500	.486	.....	....

(*) See table 1 for value of K.
(**) See page 404 of I. C. C. Annual Report. Formulæ adopted in 1923

Electric Rolling Stock

In making this report it is not the intention of your committee to enthusiastically urge hasty and rapid evolution from steam to electricity nor on the other hand, to unduly retard such development, but rather by impartial and judicious statements of facts and principles to forearm and prepare the profession for unbiased study and judgment of future problems.

That there are just grounds for hesitancy in substituting electric traction for steam on existing lines, even in the face of certain economies, cannot be denied by men well versed in such work. In the first place, electrification is very expensive. It involves a tremendous increase in the investment per mile, with the consequent difficulties, not only of meeting the additional interest and other fixed charges, but of financing the capital necessary. The art of estimating, in advance, the cost of new construction, no matter if practiced by the most competent engineers, has not reached perfection, therefore, where such large expenditures as those necessitated by electrification are contemplated, there is always the possibility that unforeseen contingent expenses may cause the estimated figure to be considerably exceeded. Changes in operating methods are often difficult and electrification immediately requires changes. In addition to educating enginemen to their new duties, a number of new men and crafts must be taken into the ranks. Transmission lines may overlap onto adjoining divisions confusing the duties of division superintendents. Signal systems have to be revamped. These and other features tend to disturb the existing order of things, and are conducive to caution and reserve.

There are a great many basic questions to be considered and answered before it can be determined whether or not electrification is the solution to a certain difficulty. Generally speaking, it may be said that electrification is prompted as a means of overcoming present or prospective obstacles and that economies in operation which obtain are of secondary consideration.

Viewing the subject broadly, it would seem that electrification of existing steam lines was not justified until after earnest effort had been made to overcome the situation at hand by applying all the refinements available in steam transportation. Of course, the cost of making such refinements and the improvements to be obtained should be carefully considered and compared with the cost and advantages that would arise from electrification. Competition may prove to be a deciding factor or public sentiment may force an issue otherwise unnecessary. Impairment to health from a smoke nuisance while in a way inconsequential to railway operation appears large in the eyes of the public and the demand for electrification, therefore, to them does not appear unreasonable.

Wholesale electrification is not desirable and it is fortunate to the railroads and to the profession that the development has been slow. It is not yet propitious to suggest standardization. It would certainly be unreasonable to urge the discarding of direct current for alternating or vice versa when a standard voltage for either has not as yet been selected. The cost is too great to countenance a complete revolution.

It is further necessary to develop the personal element, for even though it be true that steam enginemen can quickly learn to operate an electric locomotive and many other occupations also change as easily, yet, it must be remembered that certain additional occupations will be introduced and, above all, that supervisors and executives must be trained and educated to the new order of things, if the full benefits from electrification are to be realized.

Economical operation with electric power depends greatly upon the load factor and this element of operation is beyond the control of the motormen.

The report then goes on to discuss some of the changes in operation that have been brought about by the electrification of portions of some of the railroads of the United States. In each case the immediate results have been increased tonnage per train and increased train speed. These two things, whether brought about through the use of more powerful steam engines or with electric locomotives, will in themselves produce certain problems. Communication between head and rear ends of trains will be more difficult and the slack action will be more pronounced. As a matter of fact, these features are more easily overcome in the case of electrification than under steam operation because electric locomotives produce a more uniform rate of speed and are subject to closer control.

The first step is the training of enginemen for the operation of the new type of motive power. This is not a serious task, provided it is undertaken systematically by a well organized group of instructors. The first and most important thing is to eliminate all thought of mystery. The usual result of this work is the development of a set of instructions for enginemen, far in advance of any previous instructions of that nature for the operation of trains, as former practices were usually the outcome of personal experiences and not as a general thing set down in printed form.

In former years, when operating double-head or with pusher, it was the universal practice to signal by means of whistle blasts, but with the increase of train lengths this method became more and more unsatisfactory. In mountain territory, with curves and tunnels and with the long trains hauled by electric power, the whistle blast is entirely inadequate, therefore it becomes necessary to develop some other means of signaling. The method now used in electrified territories of signalling with slack action through the train, while not altogether peculiar to electric operation, it being used in some steam operated territories as well, is much preferable to the former practice and produces a much smoother train operation.

There is no difficulty involved nor is there a serious burden placed on the operator in the control of trains on descending grades through regenerative braking, in fact, the operator's task is greatly lessened for it is merely a matter of proper manipulation of his control and he is always in possession of an additional factor of safety from the air brakes with a fully charged train line. The only existing problem is that of impressing upon the motorman the necessity for the same care to insure air brake operation as with steam operation.

In regard to the methods adopted in the practical workings of electrical operation, the Chicago, Milwaukee & St. Paul uses a helper engine in their tonnage trains to assist in moving up the heavy mountain grades and retains it in position down the following grade to assist in regenerative braking.

In the operation of helpers, the helper locomotive is placed in the center of the train to as nearly as possible equalize the tonnage. This practice has been found to be desirable to eliminate excessive draw bar strain and to overcome derailments from the tendency of buckling the train.

The handling of tonnage trains on grades and curves with locomotives placed at head and middle of train has been satisfactorily accomplished by readily interpreted signals transmitted through the train. When starting a train, the lead locomotive begins to pull and the enginemen of the second locomotive, when he perceives the slack going out, applies power to his locomotive, thus starting the rear half of the train and accelerating at approximately the same rate as the lead locomotive. If the electric pusher were to push the train up onto the lead locomotive and hold the train until the lead locomotive was ready to proceed, as is customary in steam operation, the electric equipment on the helper would be subject to an unnecessarily and probably injurious overload.

In the electrified territories, there are numerous tunnels and many curves, making it impractical to depend upon hand or light signals entirely, therefore the following method was devised for testing brakes at the summit of grades before making the descent.

When approaching the summit of the grade, train is permitted to stop of its own accord and the engineer on the leading engine makes a ten to twelve pound reduction of brake pipe pressure; this is noted by the trainman in the caboose who in turn increases this brake-pipe reduction by gradually opening the brake-pipe valve in the caboose until a full service application is made or a total of twenty or twenty-five pounds. This gives assurance to all concerned that the brakes may be applied from either end of the train and are operative throughout.

The most necessary task in successfully operating freight trains is the control of the train slack in or out slowly and without severe shock. A correct understanding of this feature of handling and ability to control accordingly results in successful operation.

The time element is an all important element, and the control operations should not be hurried. This applies in starting, stopping or changing from motor regeneration or vice versa. To successfully stop freight trains, there should be no change in train slack during stop freight trains, there should be no change in train slack during the time train brakes are applied as the slack should be run in before the train brakes are applied and engineer's brake valve manipulated in a manner that will result in slack remaining run in until the train is brought to a stop.

The current required to start a tonnage train, particularly on heavy grades, is high and the train should be brought up to speed as quickly as practicable (within 15 to 20 minutes), in order to prevent damage to the electrical apparatus, especially the resistance grids. It is also more economical to utilize the electrical energy for accelerating the train to the free running speed than to dissipate it in the resistance through which the current must pass while the controller is on the intermediate notches.

When starting regenerative braking some care is necessary on the part of the engineman to avoid severe shock, due to train slack. The most practical and safe method of starting regeneration, is to make a train brake application and while this is effective make the adjustment of levers so that regenerative braking will start slowly to be effective, being governed by the speed and indication on ammeters as to the proper time to release the train brakes. The retaining valves then gradually leaking off their holding effect, permits regenerative braking to be gradually increased to full effect without undue shock to train and without causing line surges in trolley voltage. In starting from summit of grade, at slow speed and before regenerative braking is started, a train brake application is made to determine the holding power of the brakes while actually under motion. This gives those in charge the assurance of ample braking power for a possible emergency.

Overheated and cracked wheels are almost unknown in our electric operated territory, trains making a continuous and unvarying movement from summit to foot of mountain grades.

In the event the regenerative braking features should fail, which is a very rare occurrence, trains may be controlled by air brakes in the usual manner, making use of all retaining valves, and practicing the "short cycle" method of braking. This so-called "short cycle" method, meaning frequent applications and releases of train brakes, leaving it up to the brake cylinder pressure retained by the retaining valves to control the speed of the train for a greater portion of the time.

In starting on the Norfolk & Western it is customary for the lead locomotive to drop back against the train, bunching the slack against the pusher locomotive. As soon as this bunching of slack is felt at the pusher locomotive, the engineman on the pusher begins to apply power, steadily increasing it until he has maximum accelerating current on the motors. The engineman on the lead locomotive, to whom this starting impulse is readily felt, reverses his locomotive and commences to pull. The lead locomotive thus takes up the slack, picking up the train, car by car, until the load has been sufficiently balanced between the lead and the pusher locomotive to accomplish an easy moving off of the train.

Approaching a stop signal, the engineman on the lead electric locomotive reduces speed, which results in the load building up on the pusher locomotive, and this is an indication to the engineman on the pusher that the engineman on the lead locomotive desires to stop and acts accordingly, by gradually reducing the power and speed developed by the pusher. In this way the pusher locomotive keeps the train slack bunched, which is in the interest of making a better start.

When the train has reached the summit and begins to descend the grade, the load on the lead locomotive gradually decreases as the train passes over the summit. When approximately half of the train is over the summit the speed gradually increases until it reaches about 15 miles per hour, when regeneration comes into action. The uncoupling lever between the caboose and the pusher locomotive has by this time been lifted and as the train passes over the crest of the grade it leaves the pusher. The pusher drops back, crosses over to the westbound track and returns to the foot of the grade.

Track Stresses

By C. T. Ripley, Chief M. E., Atchison, Topeka & Santa Fe Ry.

In an individual paper on this subject attention was called to the increase of rail failures that had started with the rollings of 1915 and stated that we could hardly look for a decrease before those of 1919. Of the different types of failures many are undoubtedly structural or mill defects, the reduction of the stress to which the rail is put would no doubt reduce the frequency of their occurrence.

The first recorded attempts to measure track stresses in this country were made by Dr. Dudley of the New York Central Railroad, who devised an apparatus for this purpose.

The apparatus used is called a stremmatograph. This is essentially a device for measuring the strain (stretch or shortening) in a 4-in. length of the base of the rail.

The readings thus obtained are converted into terms of stress in pounds per square inch by the use of a constant, which takes into account the location of the instrument with reference to the neutral axis, of the rail, the modulus of elasticity of the rail steel, using 30,000,000 (assuming that the steel is working within the elastic limit curve where the stress is proportional to the strain) and the gauge length 4 in.

Eight instruments are ordinarily used.

It has been found that different types of locomotives and different designs of the same type, exert very different stresses on the rail; also, that the pivoting action differs. The pivot may be directly under wheels in one case and between wheels in another, and the maximum of all stresses occur at the pivot point on the inside rail. It is also pointed out that the surface friction between tire and rail may produce this high stress and it is not necessary that the wheel flange be in contact with the rail head. In fact it is not uncommon for this surface friction to induce an inward bending moment on the rail. By the same analysis, it is evident that the rail stresses are affected by the lateral motion between box and wheel hub, and also by the wheel spacings in relation to each other. If, for example, in rounding a curve the first pair of drivers exerts an excessive stress in the high rail and the second pair a low stress, then by increasing the lateral of the first pair of drivers either between the hub and box or by decreasing the tire spacing on the wheel centers, there will be a tendency to equalize the stresses, permitting the first pair of drivers to take less and the second pair more of the turning load. But, in any such change there are so many variables involved that an intelligent analysis is difficult.

As the rigidity of the frame has a tendency to cause high stresses to be exerted by the front drivers in rounding curves, or actually tends to straighten out curves, there are, of course, similarly high stresses set up in locomotive frames. The trailer may also exert high stresses partly due to rigidity and partly to the long space between the last driver and the trailer.

In order to demonstrate just what results could be secured by applying the above theories, several heavy Santa Fe type locomotives were tested with various combinations of flanged and unflanged tires. It was proven that the best arrangement was with all tires flanged, making the third and fourth drivers divide the excess strains in the low rail. The equalization was also changed so as to concentrate the load on the main drivers in an attempt to reduce the stresses under the front and rear drivers. Figs 1 and 2 inclusive show the results.

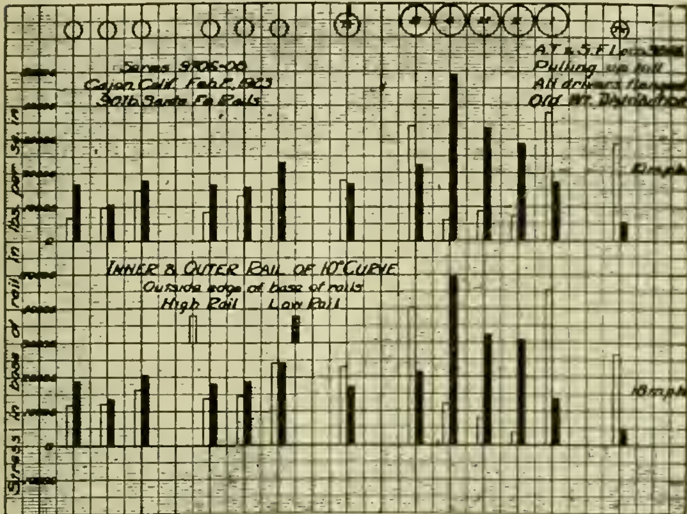
During the past year, a series of stremmatograph tests have been made on the large electric locomotives used on one of our western railways. The designers of electric locomotives generally claim that these locomotives are easier on track than steam locomotives, basing their conclusions on the absence of reciprocating parts and lower individual wheel loads. The final calculations of the above mentioned tests are not yet in shape for presentation, but the preliminary figures indicate that these electric locomotives do produce lower rail stress than the steam locomotives, particularly on tangent track at high speeds. On 10-degress curves, however, some readings as high as 50,000 lb. per sq. in. have been developed in the edge of the base of 90 lb. rail. This indicates that designers of electric locomotives should also make careful study of the pivoting action on sharp curves, as it will probably be found that these maximum stresses can be reduced just as they have been on Santa Fe type steam locomotives.

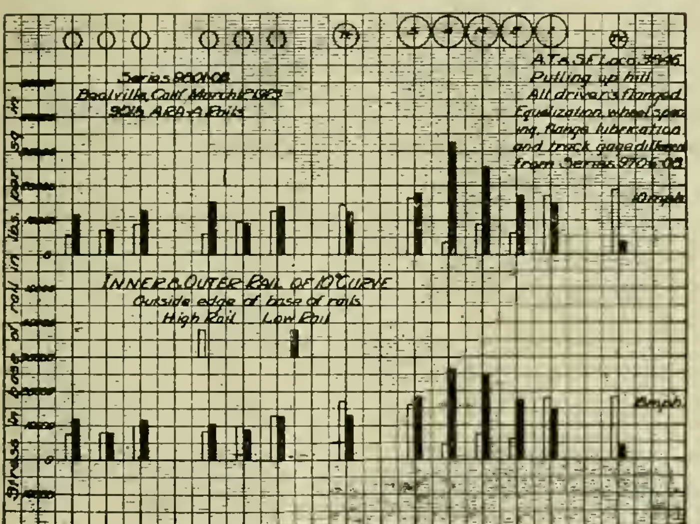
A number of new locomotive designs are being developed which it is claimed will increase the power of the locomotive without increase in weight on drivers, which is, of course, desirable from a track stress viewpoint. As examples of these developments, I might mention the three cylinder locomotive, the 50 per cent cut-off locomotive, and the booster equipped locomotive. All of these types are being actively developed and give promise of accomplishing the results claimed for them.

Up to the present time, practically no stremmatograph studies have been made to determine stresses under heavy, loaded cars. Indications are that stresses are high enough to warrant the careful consideration of car design, particularly as regards the use of four and six wheel trucks. Some figures of this kind will be available in the near future.

Most motive power officials have at some time had experience with cases of kinked rails developed by certain locomotives. These could usually be traced to stuck wedges, or to the operation of poorly counterbalanced locomotives at excessive speeds. It is not the purpose of this paper to discuss this phase of the subject, but attention is called to the fact that inasmuch as the stresses produced in the rail by modern locomotives in the best of condition are high, it is highly important that any maintenance features which tend to increase the stress should be closely watched and every effort made to eliminate them.

In considering the stresses produced by locomotives, we cannot overlook the stress produced by overbalance due to partial balance of reciprocating parts and to the fact that the forces are acting in different planes. One of the most interesting points in these stress diagrams is the effect of counterbalance. By using the standard centrifugal force formulæ we can calculate the theoretical vertical blow or dynamic augment due to the overbalance in each driving wheel. The stress records check these calculations fairly well for all wheels except the main, but here an underbalance is always recorded instead of the supposed overbalance; that is, the blow on the rail occurs when the counterbalance is up. This is a condition which calls for careful consideration by locomotive designers. In the 1917 report of the Master Mechanics' Association Committee on counterbalancing, it was recommended that no allowance should be made for the difference in plane of the counterbalance and the revolving parts as the resulting discrepancies were small. This was probably true for small locomotives, but in modern heavy power the weight of the parts as well as the difference in plane has increased to such an extent that allowance should be made. It has been noted that the lack of allowance for difference of plane results in the counterbalance for the main wheels being too small even to balance the revolving parts, let alone the reciprocating parts. This is a very undesirable condition from every viewpoint. It undoubtedly results in heavier maintenance charges due to harder service on tires, boxes, rods, pins, and brasses and is the probable explanation of some of the irregular tire wear conditions which are now being found on large locomotives. Enough counterbalance weight should be added at least to fully balance the revolving parts and this would produce a stress diagram which would show a straight line for the main driver. Unfortunately in large freight engines with their small drivers there is not always sufficient room in the main wheel centers to add this needed counterbalance. Inside bobs are one form of solution, but they are undesirable features and very large weights are necessary due to relative ineffectiveness of weight at this location. Cross counterbalancing is another line of attack on this problem which would undoubtedly be helpful. Putting the extra weight in the other drivers is not desirable as it increases the blow under these wheels and also increases the punishment of middle connection brass. In many types of locomotives, the extra weight can be added to the main driver and this should be done.





Figs. 1 and 2—Stress at the Outside Edge of the Base of the Inner and Outer Rails of 10 Deg. Curve. Heavy Santa Fe Type Locomotive 3846. All Drivers Flanged, Different Equalization and Different Conditions of Flange Lubrication, Gage and Wheel Spacing

An analysis of the balanced compound engine is of interest, as it shows that the theory that this type is perfectly balanced is incorrect. There is a hammer blow at two points midway between the pin and the counterbalance. The resulting effect, however, is not of serious consequence. All of the locomotives tested except the old light Santa Fe type referred to show reasonable track effects due to counterbalance. The average dynamic augment at rated speed is about 35 per cent of the static load. However, the total stress in rail is so high that it is quite important to do everything possible to lighten the weight of reciprocating parts and locomotive designers should continue their efforts along this line.

The diagrams showing tests on straight track indicate the increase in stress with increase in speed even under truck wheels where counterbalance plays no part. The effect of the distance between wheels is also shown. Where there is a long space, such as between the last drivers and the trailer, there is an increase in the stress. This latter condition makes the loads on trailers a feature which must be given careful consideration. Trailer wheels on large modern locomotives produce stresses as high as those under the drivers at high speeds. The only remedy in view of the continually increasing weight at the rear end of locomotives due to such devices as stokers, syphons, flexible bolts, etc., is the use of the 4-wheel trailer truck.

In conclusion, special attention is called to the progress resulting from changes on heavy Santa Fe type locomotives. The old standard arrangement was to have the main drivers blind, all others flanged and a fairly uniform distribution of weight between the different drivers. The first series of tests made on and near the horseshoe curve in New Mexico on tangent track and 6-degree and 10-degree curves, showed that some high stresses were obtained under these locomotives, especially on 10-degree curves. After the compilation of this information, both the mechanical and civil engineering departments took steps to equalize and reduce the stresses. The mechanical department considered the need and possibilities of changes in the locomotives and the civil engineering department co-operated in making 8 degrees the maximum curve in new construction. Arrangements were made to run additional tests to see what changes could be made in these locomotives to reduce the high stresses. A series of runs were made, using a different locomotive from that in New Mexico, but in the same condition as to tire arrangement and then the tests were repeated having both the main and fourth drivers blind, and also with the tire tread of standard contour and with a groove in the tread, such as exists in badly worn tread tires.

In the third series, tests were made with all tires flanged, using different tire spacings all within standard limits; then with the main drive tire blind, fourth driver tire blind, main and fourth blind; also, conditions with and without flange oiling. As a result of this series of tests, the standard practice was changed to use all drivers flanged on Santa Fe type locomotives. In the fourth series of tests, special attention was paid to the effect of the lateral motion device on the front pair of drivers on the Santa Fe type and the effect of the two kinds of trailer trucks on both Santa Fe and Mountain types of locomotives.

The next set of experiments which will be made will be with a heavy Santa Fe type locomotive, which is now being constructed with a different counterbalance. It is thought that by a change in the counterbalance it will be possible to overcome the undesirable conditions indicated in previous tests. The main wheels are to be counterbalanced, including cross balance, making allowance for differences in plane. There will also be additional counterbalance added to the other driving wheels, in order to secure a better balance of reciprocating parts. This extra counterbalance will be added to the mate wheel in each case rather than to the individual wheel being balanced in order to avoid undue increase in dynamic augment.

It is admitted that the results of individual readings of the stremmatograph do show wide variations, but there are also marked differences in conditions, and the presence of a number of very high stresses does not so much discredit the means of measurement as it shows the need for attention to reduce these stresses. The conditions of track and rail are no doubt factors that would make comparison difficult, but in a comparison stresses under the same type and weight locomotive, in the same general condition, but taken at different times, by different operators and with different instruments indicate that these figures are quite comparable.

The desirability of low rail stresses as an aid to track maintenance and safety is generally conceded and it has been pointed out how apparently small details in locomotive construction affect the track stresses produced. Representative stress diagrams, the results of numerous tests, have been shown and the marked changes of these diagrams with changes of locomotive condition are strong arguments in favor of the practicable application of track stress measurements as an aid to track maintenance and the improvement of locomotive design. Furthermore, reduction in rail stress will result in corresponding reduction in stresses in certain locomotive parts and therefore the locomotive designer by giving consideration to this question will not only reduce track maintenance costs but also locomotive maintenance costs.

Wheels

The committee stated that it had kept in touch with the progress made in the application of the new cast iron wheel specifications which were adopted last year. These specifications contain some rather revolutionary features, particularly as regards chemical composition. It was thought at first by some of the manufacturers that they would be very difficult to meet. However, the Association of Wheel Manufacturers decided to co-operate in securing their adoption and from reports received by the Committee, the railroads are gradually going to their use either in exact form or with slight modification as to wording, and in some cases with extra requirements. The majority of the manufacturers are apparently able to meet the specifications, though some foundries have found it necessary to make changes as to materials and equipment. This latter development is, of course, very desirable, as better wheels will be the result. It is too early to make an analysis of the results secured in service by wheels made under the new specifications, but we have some indication of what may be expected by referring to the thermal and drop tests made by railroad inspectors at the foundries. In order to amplyfy this information, some of the railroads have had their inspectors carry the thermal tests and drop tests to destruction wherever possible, rather than stopping at the specification limits. This procedure has developed some rather interesting information, and shows that in certain foundries the wheels will stand for much longer periods of time in thermal tests, than wheels produced by other foundries, though both types of wheels meet the specifications. The difference in results of these tests indicate the value of proper annealing and the cleanliness of iron in the plates. The Committee will continue to watch the performance of the new specification wheels.

The specifications for rolled steel wheels, which were adopted last year, do not contain any provision regulating the methods of cooling rolled steel wheels, as used by the manufacturers. While the Committee realizes that the methods of cooling are a very important factor in the strength of the wheel, it did not feel that the subject could be covered by specifications, as it was a detail of manuture, which should be left to the manufacturer. This subject has been given a great deal of thought by the various manufacturers for a great many years, but apparently they have not arrived at any uniform method of handling this work. The Committee members, in their visits to wheel manufacturing shops, have watched these different practices and it is their feeling that some of the methods which are being used could be improved. The strength of rolled steel wheels which is a very important matter, particularly because of their use under locomotives and passenger cars and every precaution should be taken in manufacturing to avoid breakage in service. The Committee plans to make hardness tests and microscopic examinations of sections cut from wheels, which have been put through various cooling processes and endeavor to determine which process gives the better condition. During the coming year, they will take this matter up in joint session with manufacturers of rolled steel wheels, in an effort to arrive at some uniform practice which will be considered as the most satisfactory. It is possible, as a result of this study, that some clause can be worked up to add to the specifications, which will prescribe certain qualities in the finished wheel, which will necessitate the use of the best cooling methods by the manufacturer.

Suggestion has been made that the wheel committee prepare specifications for cast steel wheels, due to the fact that a large number of these wheels are now in service and passing over other roads than those which purchased them. It was felt that some protection should be afforded roads, operating cars with these wheels under them, by the use of a standard specification. However, there is only the one manufacturer who makes this particular type of wheel and it involves certain patented processes. Under these circumstances the Committee does not feel that the present time is right for the issuance of any standard specification. It is possible that in the future some other manufacturers may develop a cast steel wheel and if this occurs it will probably be necessary for the Association to have a standard specification for the protection of purchasers. The Committee has, in co-operation with the manufacturer, worked up a tentative specification and if any purchasers of cast steel wheels desires the assistance of the Committee in connection with this matter, they will be glad to assist them in the preparation of a specification for their individual use.

During the past year, manufacturers of cast iron wheels have continued their intensive study of foundry practice and wheel design, in an effort to improve the quality of their product. New types of cupolas have been put into service and the results look very promising.

The outstanding development in new designs is the single plate wheel and the A. R. A. type with reinforcing rings. The single plate wheel, particularly in the heavy weights, has shown up very well in experimental thermal tests and gives considerable promise of successful development, though it is, of course, entirely in the experimental stage at the present time. The development of reinforcing rings, referred to above, is the result of attempts made to overcome the difficulties due to collecting of dirt in the plate of the wheel. The old M. C. B. type of wheel had a projection point at the intersection of the plates, which tended to skim off the dirt from the molten iron as it flowed out through the mold, and it was found that this produced a weak point in the plate. The change to the arch type wheel overcame this difficulty, as this projecting point was eliminated. However, the total amount of dirt in the plate was the same though it was scattered rather than concentrated. Wheels which break through the plate in service will very frequently be found to have dirt collections at the point of breakage. If new wheels have the front plate machined off, it will be found that there is a considerable amount of dirt, which undoubtedly is a weakening element. In order to overcome this, one of the wheel manufacturers developed a design which includes three raised rings on the outside plate. These rings serve as skimmers for the iron and tend to collect the dirt and slag, as it flows out through the mold. The main plate of the wheel is thus made of clean iron. Experimental thermal tests of these wheels indicate that these rings serve the purpose and strengthen the wheel as they apparently stand a more severe thermal test than do the standard design wheels. Furthermore, when broken up, these reinforcing rings are usually found to be of a very dirty metal. One railroad has arranged to put 1,000 of these wheels in service in order to demonstrate what service results can be secured and thus assist the manufacturers in proving the possibilities of this design.

Trouble has been experienced with the wheel mounting gage where wheels are worn in the tread and it has been found to be impossible to have the two contact points to strike the flange and tread respectively.

This mounting gage was primarily designed for use on cast iron wheels and when it is used on steel wheels certain conditions are found to exist which make it unsatisfactory. In the case where two sharp flanged wheels are mounted together the gage results in improper mounting. That is, when the wheels are turned they will be found to be spaced too wide. This practice of mounting two sharp flanged steel wheels is common practice on many roads, as they dismount sharp flange wheels to remate, in order to save metal on mate wheel.

The opinion of the Committee as to the proper way to mount rolled steel wheels is to use a spreader gage, such as is used in mounting locomotive tires. This gage should be 53⅜ in. in length. The Committee does not recommend that this gage be made a standard gage of the Association, but suggests that the individual railroads equip themselves with this type of gage for use in checking the mounting of rolled steel wheels, as it is their belief that the results will thus be made more satisfactory.

In the 1923 report, the Committee stated that it would make further investigation of the question of taper on tread of cast iron and steel wheels and give special consideration to the possibility of using straight taper instead of double taper. It appears that both the New York Central and the Baltimore & Ohio have adopted the straight taper type of tread on all cast iron wheels. The Baltimore & Ohio has a straight taper on its steel wheels, and the New York Central has adopted a modified double taper; the length of the second taper being reduced to 1 in. The New York Central uses 1 in 38 and the Baltimore & Ohio 1 in 13 taper, instead of 1 in 20, which is standard for A. R. A. The theory on which the New York Central changed their taper was that they wished to improve the relations between the wheel tread and rail, with reference to area of contact. The Baltimore & Ohio change in their taper was designed to increase the life of wheels by reducing flange wear. The Committee feels that there is not sufficient data available to prove just what advantages may be expected from these changes. From a theoretical viewpoint, it appears that a straight taper is the correct design, but before recommending any such change there should be definite test data available. It is planned to run a series of tests during the coming year, which will indicate the relative wheel life with the various tread designs.

In this same 1923 report the wheel committee made a strong recommendation for the practice of grinding slid flat cast iron wheels and also suggested that the railroads give consideration to the grinding of new cast iron wheels where the machinery was available in order to make them truly round. We regret to state that there has been very little development of this practice of grinding wheels on the various railroads.

The question has been raised during the past year, as to why it was not permissible to use rolled steel wheels down to the freight car limits of ¾ in. under switch engine tenders. Some carriers feel that this is a simpler way to use up the scrap wheels out of their road locomotive tenders. The wheel committee can see no objection to such practice, since cast iron wheels are used on many roads for this same service. The Government rules, however, set a limit on this service of 1 in., and it will, therefore, be necessary to have this changed before a railroad can wear the wheels to ¾ in.

Election of Officers

John J. Tatum, superintendent of the car department, Baltimore & Ohio, was elected chairman of the division and J. T. Wallis, chief of motive power of the Pennsylvania System, vice-chairman. The following members were elected to the General Committee: Alexander Kearney, superintendent motive power, Norfolk & Western; C. F. Giles, superintendent machinery, Louisville & Nashville; L. K. Sillcox, general superintendent motive power, Chicago, Milwaukee & St. Paul; John Purcell, assistant to the vice-president, Atchison, Topeka & Santa Fe; G. E. Swart, chief of car equipment, Canadian National; C. E Chambers, superintendent motive power, Central Railroad of New Jersey; C. H. Temple, chief of motive power and rolling stock, Canadian Pacific; J. C. Fritts, master car builder, Delaware, Lackawanna & Western; O. S. Jackson, superintendent of motive power and machinery, Union Pacific; F. H. Hardin, chief engineer motive power and rolling stock, New York Central; W. H. Fetner, chief mechanical officer, Missouri Pacific, and A. R. Ayers, assistant general manager, New York, Chicago & St. Louis.

The following were elected members of the Nominating Committee: F. W. Brazier, assistant to general superintendent rolling stock, New York Central; H. T. Bentley, general superintendent motive power and machinery, Chicago & North Western; J. J. Hennessey, assistant master car builder, Chicago, Milwaukee & St. Paul; C. E. Chambers, superintendent motive power and equipment, Central Railroad of New Jersey, and W. J. Tollerton, general superintendent motive power, Chicago, Rock Island & Pacific.

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The June Convention

Dickens opens his Tale of Two Cities in the statement, "It was the best of times, it was the worst of worst of times;" or, in other words the expression of the optimist and the pessimist that have come echoing down to us through the ages. So in spite of the imposing and valuable display at the recent convention we still find opposed expressions as to its worthwhileness.

To start with, it seems to be the opinion of some railroad executives that the whole affair is a sort of sanctioned debauch; that it takes men away from their home duties where they could be much better employed and lets them loose upon a sort of irresponsible junket. Possibly this opinion is based upon their recollections of earlier days when they were not occupying executive positions but were one of those who partook of the somewhat irregular festivities that were the rule at the time.

As for the members of the association they are pretty well agreed as to the value of the conventions, both from the standpoint of the meetings and papers and of the exhibits.

So that railroad circles, when taken as a whole, present the appearance of a camp divided for and against, in which it is to be remarked that the fors consist of the men who are intimately associated and thoroughly conversant with all of the varied aspects of the convention and the againsts are of those to whom the technical aspects are but a partially opened book; who look upon the exhibits as an example of lavish extravagance, and whose opinions rest to a great extent on impression and hearsay.

When the exhibitors, the men who pay the bills formed an organization, pooled all public entertainment and then started on a career of extravagance, the inevitable reaction took place and the present sane methods were adopted. But it is interesting to note that ever since the pooling of the entertainment took place, there are some that have no use for the conventions, though always in attendance and most particular as to the space that they occupy.

With the railway supply men, those in favor of the convention constitute the great mass of exhibitors who occupy one or possibly two exhibit spaces. Men who are always to be found in the same place year after year, some of whom have held the same spaces for twenty years, and whose exhibit has scarcely varied in that time. Men who say that they have built up their business by these annual shows. Men who say that they regard them as invaluable, and that it would cost them a million dollars to reach the men who come to them of their own accord at Atlantic City. Men who ask, how could I take that stuff to a man's office and how could I get him to come to my shop to see it? These men constitute a great majority. The only point that devides them is as to the advisability of having the meetings annually or biannually.

Actual sales and orders are of course somewhat infrequent but occasionally they are of considerable magnitude.

There is no longer a complaint that the exhibits are not visited for a systematic inspection has become the rule among the members.

Now what does it cost?

The lavish decorations for the whole pier will run less than two thousand dollars and the office expenses of the organization is about as much more, while the total cost, including pier rental, is a little more than $75,000, or about $100 for each member of the association.

Is it worth while or is it not? The answer depends upon the point of view of the one who answers, but when the greatest good to the greatest number is concerned, and this includes the railroads, the public and the supplymen, it looks as though a pretty strong case could be made out for the affirmative.

Grade Reduction, the Booster and the Heavier Locomotive

The object of each of the three is to increase the tonnage capacity of the railroad, and the decision as to which it shall be is the solving of a rather complex problem. Each has its advantages and each must be considered not only for itself but in the light of its relationship to the other two.

Of the three, the grade reduction alone presents a permanent investment that does not wear out and that entails no increased cost of maintenance. It represents an investment that permanently reduces the tractive effort required to move a given tonnage over a definite portion of the line.

It is usually applied to ruling grades that are the limiting factors in determining the tonnage rating of the engines. If this ruling grade is reduced, tonnage rating of all engines can be permanently increased, and every extra ton so hauled contributes its portion to the interest charge on the cost or to the sinking fund that is to wipe it off the books.

But grade reduction may result in a decrease in tonnage if its capabilities are utilized to the utmost. Suppose a division 125 miles long with a ruling grade 5 miles in length on which, with the tonnage rating in vogue, the speed is reduced to 5 miles per hour, which over the remainder of the division it can be held at 15 miles per hour. This would make the running time for the division 9 hours. A grade reduction that will permit of an increase of tonnage over that section, but which would reduce the average for the division to 12 miles an hour, would increase the running time to 10 hours and 25 minutes.

Whereas a heavier locomotive that would reduce the time over the ruling grade would also make a corresponding increase over the remainder of the division. Or if the tonnage were increased so as to hold the old speed over the ruling grade the total time over the division would be the same as before, or less with the same tonnage.

The same holds true with the booster, except that, as it is not intended for use at high speeds, it would only be available on the grade at low speeds and could not be utilized for acceleration in running for a momentum grade.

From these considerations it is evident that no hard and fast rule can be laid down for the adoption of any one of these three methods for increasing tonnage to the exclusion of the other two, and that, in every case, local conditions and the peculiar individual characteristics of the traffic to be handled must be given most careful consideration.

The Poor Railroad Was Taxed to Death

Our good friend Mr. J. W. Murphy of the *Saturday Evening Post* of Burlington, Iowa, tells us that the tragic career of the Muscatine, Burlington & Southern Railroad forms an interesting lesson in psychology. Thirty years ago public meetings of vehement interest were being held to the whys, ways and means of bringing this ambitious little line into Burlington, Iowa. Orators of these occasions assured the audiences that the railroad would give an impetus of major consequence both to jobbing and retail interests. While the subscriptions were not liberal, they were sufficient to bring the line into Burlington.

For 25 years the community has enjoyed the benefits derived from train service on this road. Except for one brief twelvemonth, operation of the line showed loss. Receiverships and reorganizations followed each other. Now comes the complete collapse, to be followed by disintegration. Some features of the affair are impressive. For example, the three Iowa counties served by the road are demanding payment of $56,000 back taxes. Now, who but a dunce would imagine that a small railroad could ever pay such taxes? These tax bills alone would have driven it into bankruptcy. The communities served by this little road were enthusiastic to get it built and operated. Then they turned around and taxed it to death. And now they are wondering why it couldn't be made to pay its way. Solomon, the all-wise, said, 26,000 years ago: "Though thou shouldst bray a fool in a mortar, among wheat, with a pestle, yet will not his foolishness depart from him."

The Railways as Empire Builders

An attempt to review the history and development of the United States without touching upon the railroad problem, would be about as easy of accomplishment as an attempt to write a history of the steam engine without mentioning Watt or Stephenson.

We have recently been favored with copy of monograph entitled, "Tractive Power and Hauling Capacity of Steam Locomotives," by John E. Muhlfeld, in which the author not only subjects all technical phases of the question to careful analysis, but also touches on the other inseparable angle of the steam locomotive, and the part it has played in the development of this country, and it is with particular reference to this latter feature, the economic one, rather than purely engineering points that we shall principally touch upon.

Economic and Political Features

In view of the repeated misstatements of many Senators, Congressmen and others who by acts of omission and commission have contributed to a temporary slacking of business activity and the impairment of railroad credit, we quote from Mr. Muhlfeld's paper items one (1) and two (2), and wish to point out the lessons that may be learned by a careful study of these facts and principles as set forth, together with a comparison of conditions then and now.

"1—The railroads of the United States have been built to develop its national resources, to make waste or unproductive lands valuable to the people who locate on and own them, to transport the products of industry from one section to another, to build up manufacturing centers which will enable us to compete with the markets of the world, and to provide protection in time of stress. They are the one great agency through which our country has been, and today is being, developed and forged to the front as the leading nation of the world, and they are not the barnacles that retard the progress of our Federal and State institutions, as some people, whose principal occupation is to interfere with distribution rather than to stimulate producion for our increasing population, would have us believe."

"2—Experiences and observations on various railways in the United States and Canada have been that it requires many years of struggle, hard work and rigid economy before they can be made to yield returns to the stock owners, and in view of the many and constantly growing number of obstacles to be contended with, steam railway employes have every reason to be extremely proud of their accomplishments. Had it not been for the ingenuity of those in charge of roadway, structures, and equipment in devising, perfecting and executing the rectification of gradient and curvature, strengthening of tracks and bridges, and increasing the size and efficiency of locomotives and cars, the majority of the railways would long since have been bankrupt. Likewise were it not for the many methods of operating economy devised and practiced by the steam roads during the past twenty (20) years, of which the adjusted tonnage rating of locomotives has been one of the most important, the shippers would be paying much higher freight rates, or the employes would be receiving much lower wages, or both. In fact, the railroads have been, and are now, between two independently controlled millstones—the upper representing increased cost for wages, materials, supplies, equipment and other facilities, and the lower representing inadequate rates, increased taxes and burdensome laws and regulations."

To come direct to the point and pay our respects to certain men *much* in the public *eye* and strongly attached to the public *payroll*, let us see what the railways have done for the farmers, and if either the individual, corporation or State, is entitled to enjoy the unearned increment, or increased values resulting from the development of a new territory.

For the purpose of this illustration we will take the States of Iowa, Minnesota and Wisconsin. Showing farm values at two different periods in their history:

	Farm acreage and original cost		Present value of farms valued at
State	Farm acreage	Value at $1.25 per acre	$100 per acre
Iowa	33,474,896	$41,843,620	$3,347,489,600
Minnesota ..	30,221,758	37,777,197	3,022,175,800
Wisconsin ..	22,148,223	27,685,278	2,214,822,300
Total	85,844,877	$97,306,095	$8,584,487,700

The three States above are selected for the reason that senators from each of these States are noted for their loose talk about the wickedness and corruption of the railways, which they were going to "Sail Right in and Correct" the first thing on their arrival in Washington. In fact from their reported public utterances, threats and ravings last fall, one might have looked for much blood-shed if things were not handled to suit them at Washington, but at last accounts they have simmered down as it were as most all windy politicians do, to drawing their breath and salary, the latter being the most important.

One of these Solons shouted from the house tops that he had discovered $7,000,000,000 of water in railway securities, and that he was going forthwith to extract it. Well, up to date he has not located enough water to "charge a squirt gun."

Another Solon blamed the Government and the railways because the farmers gambled in high priced land, and planted some 8,000,000 or 10,000,000 too many acres of wheat, thus through their own lack of foresight or "common horse sense," glutting the world's wheat market, reducing its price, resulting in economic loss for which they were themselves to blame.

These self-styled national leaders are loud in their demands for:

(a) Reduction in freight rates.

(b) Government ownership of railways, and many other radical changes that would benefit politicians and their following, but most of all of which would be detrimental to the country as a whole.

During the entire crusade against railway interests principally waged by men in high official positions who claim to be fair and honest, so far as we know, *not one* of them has as yet shown himself to be square enough to admit that it was the railways that created this unearned increment in land values, for the land itself is *no richer* in potential productiveness than the virgin soil that cost $1.25 per acre or less, and any man who either denies the railway proper credit for this increased valuation, is either densely ignorant or not on the square.

The steam locomotive, as pointed out by Mr. Muhlfeld, has made this possible, and not the politicians at Washington or elsewhere.

If some of our lawmakers are really in earnest in the matter and actually want to be fair to the railways it might aid them in this direction if they would post up a little by listening to the opinions of some, who though vitally interested financially in the rate question, cannot be led into an indefensible or false position.

Of numerous examples this one may serve to illustrate this point:

A heavy shipper of cattle from the West, who is also president of the Stock Grower of his State says:

"Our former rate on livestock shipments from Miles City to Chicago was 48c. It is now 59c, or an increase of about 23 per cent."

In considering the question of a reduction, or the fairness of the present rate we must bear in mind the following facts as to the increased expense of the railways to produce this transportation, which among others includes the following:

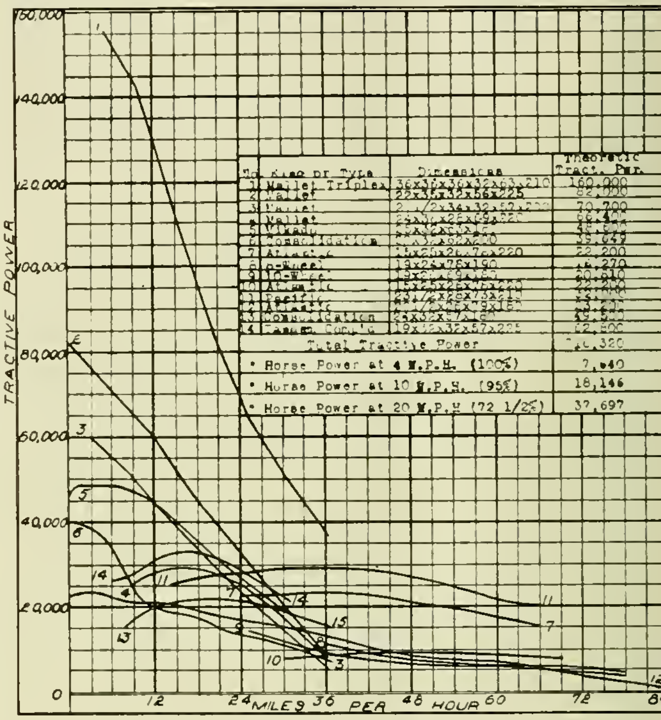
Items	Cost with 48c rate	Cost with 59c rate	Per cent of increase
Locomotives, fr'gt....	$16,243.00	$53,553.00	
Locomotives, pass....	$16,057.00	$66,200.00	
Freight cars.........	800.00	$ 2,000.00	
Switching engines....	11,860.00	39,000.00	
Rails	28.00	43.00	53
Ties................			
Bolts and fastenings..	2.45	4.30	75
Passenger cars.......	7,300.00	28,900.00	
Refrigerators	1,500.00	3,000.00	
Labor, daily av. of all..	$2.20	4.93	123
Fuel	$1.15	4.00	246
Taxes	.544c	$1.24	128

After looking over these items it is evident that the rates are relatively lower now than they were then and unless the railways cost of living can be lowered we should not expect a reduction in freight rates.

Technical Feature

Passing from the economic or political phase of this matter, there is one feature of the author's paper in which we wish to concur and amplify by the introduction of a graphic chart showing how speed effects both tractive and horsepower on fourteen (14) different locomotives.

A study of this chart not only confirms the author's tabulation and conclusions, but emphasizes the fallacy or danger of trying to operate even at moderately fair rate



Horse Power—Tractive Power Multiplied by Speed in Miles. Divided by 375.

The Tractive Power at Different Speeds is Shown in Percentage of the Total

The Tractive Force Developed by All Engines at Different Speeds Is Based on the Relation between Maximum Theoretic Tractive Power and Heating Surface, as Shown by Curve in Baldwin Formulae of Percentages, Using Average Ratio of 10 to 1

of speed, engines designed and built for low speed drag service.

Following are some of the more salient points to be brought out:

1. It will be observed that engine No. 1 with a tractive power of 160,000 lbs. at five miles per hour, and could have a drag train of about 22,000 tons at that speed, has less than 100,000 lbs. T. P. at 18 miles per hour, and at a speed of 27 miles per hour has only 60,000 lbs. tractive power, or a drop in tractive effort of 100,000 lbs., which emphasizes the fact that power of this kind is designed only for special low speed drag service and should never be used elsewhere.

2. Another rather striking illustration of the fallacy of trying to make speed records with heavy truck horses will be found in a study of engines 2 and 3 as compared with engines 5 and 6. The two first engines, 2 and 3, have a tractive power of 82,000 and 66,000 lbs., while the latter have 48,600 and 39,649, a little more than half of the combined tractive power of the former. Yet at a speed of 15 miles per hour No. 5 excels No. 3 in T. P., while at 36 miles per hour the Mikado and Consolidation excel the two Mallet engines in T. P.

3. The curves for engines 7-8-9-10-11 and 12 are of course for passenger engines designed for sustained efficiency at the high rates of speed necessary in that branch of srvice.

Mr. Muhlfeld's treatment of the entire subject is a valuable addition to railway engineering literature.—W. E. S.

The Development of Railroad Regulation

By Frank McManamy, Commissioner Interstate Commerce Commission

Address Before the Mechanical Division Meeting of the A. R. A.

No railroad organization can boast of a wider zone of usefulness or a better record of achievement than the Mechanical Division of the American Railway Association and on no class of men will the future burdens of the transportation industry rest more heavily than on those responsible for the design, construction, and maintenance of the instrumentalities of transportation.

Transportation is the oldest and the newest problem confronting civilization. It is the one problem solved by every age and yet by every age to be solved. From the day when Mother Eve packed her fig leaves and called on Adam to transport them out of the garden, transportation has been essential to human well-being and happiness, and has perhaps more accurately reflected human progress and achievement than any other industry, not excepting agriculture.

The first railroad is less than 100 years old. In fact the first railroad was incorporated in 1827, and in 1830, 95 years ago, there were only 23 miles of railroad in operation in the United States. Prior to that time the transportation facilities were such that a journey of a hundred miles was the event of a lifetime and something to be dreaded rather than enjoyed. When we compare the facilities at that time with our present magnificent transportation facilities which make travel a delight and distance a delusion, no one who has had any part, even remote, in bringing about this improvement can avoid a feeling of pride at the result. But we have no time to spare for felicitation. The complexities and exactions of modern civilization which have in fact been fostered and made possible by our improved transportation facilities constantly demand better, safer, more convenient, and more efficient service. That is the problem which now confronts the members of this association.

For the energy and constructive genius of the leaders in the early stages of railroad building and development, the so-called empire builders, I have feelings of the most sincere admiration but not of awe. They conceived and carried to completion undertakings which were of tremendous importance in the development of this wonderful country, but their motives were no different, no nobler, or more patriotic than those of other men who along other industrial lines contributed towards our present industrial development. To the extent that their plans were a gamble, they were usually gambling with stakes provided by someone else. While we owe them our admiration for the aggressive way in which their undertakings were conceived and carried out, we owe them nothing more. Their problems were no more difficult and their ability and energy no greater than are possessed by the railroad men of today. Opportunities to exercise ability and initiative in the solution of such problems and the rewards which would come from a successful solution were no greater than that exist today.

Transportation is a public necessity, therefore a public function, and under the present policy of the American people, is to be conducted under a system of adequate governmental regulation. Railroads are primarily public highways and only incidentally common carriers—an important distinction too frequently overlooked. The solution of our transportation problem is therefore not a matter which rests primarily with the railroads or with any State or Federal regulating body, but with the people who require transportation and who are required under the Constitution to pay a reasonable return for the transportation furnished. The solution of the transportation problems should therefore be approached in a spirit of "let us reason together" and should be worked out along broad lines of public policy and in the public interest.

In view of the importance of the problem and of the part which legislation must necessarily play in its solution, a brief review of the scope and effect of what the Government has done in the way of legislation affecting railroads may be of interest and give a clearer understanding of the situation. There are few of us who realize that the greater part of the legislation has been to help transportation. I am speaking now of the transportation machine as distinguished from the corporation which operates it. We must bear in mind that it is the duty of the Government to see that adequate transportation is provided just as much as to construct and maintain public highways, and that it has only delegated the duty of furnishing transportation to private corporations.

While the right of the State to regulate common carriers dates back several centuries, a right which has been sustained by an unbroken line of court decisions down to the present time, regulation of railroads, as we now know it, is less than 40 years old.

The power of the Federal Government to regulate transportation rests upon the third clause of section 8 of article 1 of the Constitution, which provides that Congress shall have power "to regulate commerce with foreign nations and among the several States." This provision was agreed to in the Constitutional Convention without a dissenting voice and it grew out of the difficulties arising from the failure of the States to agree upon a uniform regulation of commerce under the Articles of Confederation.

A survey of the development of the railroads discloses that there are at least six distinctive periods in railroad regulation. The first period, from 1830 to 1870, was one of railroad building with absolute freedom from Government regulations. The attitude of the public and the Government was one of liberality and encouragement. During the latter part of the period the complete absence of Government regulation allowed the prosecution of self-interest to run wild. Unscrupulous persons derived large personal gain at the expense of the transportation system.

Second Period

The period from 1870 to 1887, might be designated as the beginning of railroad regulation. About 1870 the attitude of the public changed from that of encouragement and became less favorable towards the railroads because of the system of preferential rates, rebating, and scandalous financial manipulations. The practice of rebating was extensively indulged in, particularly as to large shippers. These practices caused much dissatisfaction. The first laws were passed by the Middle Western States between 1871 and 1875 and are what is known as "the Granger Laws," which dealt almost entirely with discrimination and rebating. This legislation was upheld by the Supreme Court in the so-called "Granger Cases."

Because of the methods followed at this time several investigations were instituted by different Governmental bodies. The investigation by the Cullom Committee of the United States Senate in 1886 resulted in the enactment of the first Federal legislation regulating railroads,—the

Act to regulate commerce of 1887. This Act was primarily designed towards preventing discrimination and rebating and did not empower the Commission to prescribe reasonable rates. The other provisions in the original Act were subsidiary to the accomplishment of the main purpose, and had to do with the publication of charges so that every one might know what they were, requirements as to accounting practices to facilitate the discovery of irregularities, etc.

While this law was primarily to prevent discrimination between shippers, it was of great help to transportation as it prevented extortion by large shippers. Large shippers, such as the Standard Oil Company and the packers, could force rebates out of the railroads because of the amount of traffic they controlled. Leading railroad men appeared before the Cullom Committee in 1886 and advocated a law to stop rebating, stating that the large shippers practically held pistols to the heads of railroads and not only forced debating, but dictated the service to competitors. Vanderbilt told the committee that if the rebating kept on, the oil people would eventually own the railroads. The losses of the railroads from this source cannot be estimated accurately, but one official said in 1888 that the gross receipts of the railroads in round figures were about $800,000,000 per year, and that he believed $100,000,000 of that had been paid out as rebates to large and powerful shippers. There were various other forms of rebating which deprived the carriers of much revenue—such as passenger rebating to large concerns, etc. The freight rebating, however, was the greatest item and the discounts frequently amounted to as much as 50 to 80 per cent of the tariff rates.

The Third Period

From 1887 to 1906 might be called the period of development of Federal regulation. Most of the additional legislation enacted during this period was of miner character to help out the administration of the Act of 1887. The amendment of 1889 required the railroads to give certain notice of reductions preventing the so-called "midnight" tariffs which were used to favor large shippers. Because of the difficulty in obtaining evidence, the Compulsory Testimony Act was passed in 1893. The trouble in enforcing decisions caused the Expediting Act of 1903. The original Act was not sufficiently strong to prevent various forms of rebating and the Elkins Act of 1903 was, therefore, enacted to strengthen the law.

An amendment to section 10 in 1889 made it a penalty for shippers to false bill freight in order to obtain cheaper rates. The commission, through its Bureau of Inquiry, compels the observance of that section. The original Safety Appliance Act of 1893 was intended to promote safety, but it has in many ways promoted efficiency in operation, and this is also true with respect to the locomotive inspection act and other safety legislation enacted later.

Fourth Period

From 1906 to 1917 was the first period of real regulation. The Hepburn Act of 1906 broadened the field of Federal regulation. The most important feature was the authority of the Commission to prescribe just and reasonable rates. In the Mann-Elkins Act of 1910 the effectiveness of the fourth section was restored. The observance of this section is of great help to the transportation machine as it in a measure prevents wasteful service.

In the 1906 Act the Commission's jurisdiction was extended to include all instrumentalities or facilities for shipment regardless of ownership, in order to give control of the private car lines and the so-called industrial roads and prevent extortion from the railroads by large shippers. After the passage of the Act of 1887 there were several ways by which large shippers could legally demand rebates from the carriers. Many large oil companies and other shippers owned their own cars; the packers owned their own refrigerator cars. The large shippers furnished their cars for the transportation of their products and obtained excessive payments for the use of their equipment as well as exorbitant refrigeration charges in connection with their refrigerator cars. In an investigation before the Commission in 1904 the president of the Santa Fe and the president of the Great Western testified that their roads did not like to be dictated to by shippers, but because of carrier competition they could not help it.

Another form of extortion which grew up after 1887 was by small terminal roads. Producers incorporated switching tracks or sidings into a railroad and thereby secured a large division of the rates. This form of rebating spread rapidly. The first case of record that I can find was the investigation of the salt trust in 1903. This concern owned 9 mines at Hutchinson, Kansas, and had one mile of tracks around the works. It incorporated these tracks as the Hutchinson & Arkansas Railroad. The railroads agreed to give this midget road as a division 25 per cent of the rates to Missouri River not to exceed 50 cents per ton, which was equivalent to an amount ranging from $15 to $20 per car. The steel and lumber companies organized many of these miniature roads. A large company at Chicago organized its switching lines into a road and received a division of about $12 per car. Up to about 1905 it had received rebates in this manner amounting to about $3,000,000. All of this led to the passage of the provision as to allowances in section 15, preventing the payment of a sum greater than the cost of the service.

Other legislation was enacted during this period which was helpful to the transportation machine as a whole. The commodities clause in the Act of 1906 made it unlawful for a carrier to transport any commodity which it owned or produced other than lumber. This clause prevented railroad corporations from engaging in another business and transporting their products at a cheap rate to the detriment of transportation. In 1906, section 1 was amended so that carriers could be required to make physical connections with lateral branch lines of road.

Up to 1920 Government regulation was confined mainly towards restraining abuses of transportation rather than something constructive. Important phases of the railroad problem that had been left unregulated were capitalization and service. Railroads up until that time had absolute freedom in the issuance of securities. The lack of authority to regulate security issues tended to obscure the relationship between the railroad investment and railroad earnings, and also to lend color to the widespread opinion that the railroads were over-capitalized.

The regulation of service was likewise neglected. The problem of adequate transportation service had received little attention. Because of competition shippers were in many cases treated with liberality and wasteful service became a matter of routine. These defects were realized during the first year of the war period, 1917, when the necessity of providing adequate service was paramount. Because of traffic congestion and car shortage, Congress in 1917 enacted the car service section, giving the Commission jurisdiction to establish and enforce rules and practices with respect to car service.

As a result of several conditions the transportation service in the latter part of 1917 was inadequate to handle the unusual traffic burden of the war period. The necessity for complete unification during the extraordinary war conditions resulted in Federal control.

Federal Control Period

I do not intend to discuss the relative merits of private operation as against Government operation during Federal control; whatever may have been its faults or its virtues the responsibility rests with you. The principal lesson of Federal control was to demonstrate the possibilities of and need for unification. People saw the advantages of unified use of equipment and facilities and of uniform standards of service and operation. While the improvements in operating practices during Federal control were not fully recognized due to war conditions, they did have an important and direct influence upon the policy of the legislation enacted when the railroads were restored to private management. A number of emergency measures were passed during Federal control, but I shall not refer to them here.

At the end of Federal control, the railroads were turned back with a reconstructed system of Government regulation. The Transportation Act of 1920 was designed not only to cure defects in old legislation but to give assistance to the transportation industry. While it provided financial safeguards for the maintenance of railroad credit, the main problem was to provide for co-operative effort and to stimulate the fullest possible utilization of the transportation plant through unification. In commenting on the serviceability of this Act in the solution of these two problems, I want it understood that I may not agree with the wisdom of certain of its provisions.

Period Beginning in 1920

The new legislation can well be divided into two general groups: (1) Provisions dealing with unity of operation and service; and (2) provisions to stabilize credit. A series of laws were also passed dealing entirely with the termination of Federal control, but they now possess only a historical interest. Provisions were also made for temporary loans to the railroads until their credit could be re-established.

Unification

The new legislation proposes to secure the fullest use of the existing plant through permissive consolidations. The Commission must draw up a plan for consolidating all roads into a limited number of systems and the railroads may then consolidate in conformity with that plan. The theory of the law is that the weak and the strong roads will be so consolidated as to form evenly balanced systems and that such consolidations will result in more effective utilization of plant and equipment, prevent duplication, and be the means of attaining an operating unity.

The Act also provides that before any new road or extension can be constructed, the Commission must first find such construction to be in the public interest and give its approval with a view to building up a transportation machine responsive to public needs.

The car service section was broadened. This section prohibits discrimination between carriers, and is a positive factor to provide adequate service and facilities. The public control over service acquaints the regulating body with the needs of the carriers and brings forcibly to its attention the necessity for adequate rates. Along this same line, the Commission was given power to require the joint use of terminal facilities in order that the transportation plant might be fully used to meet public needs. The unification of facilities means economy and efficiency in operation.

Provisions to Stabilize Credit

The other main purpose of the Transportation Act was to assist in stabilizing the credit of the railroads and several provisions were inserted for that purpose. The level of rates, railroad credit, and capital investment are interwoven subjects.

The Act recognizes that transportation must have sufficient revenue to attract capital. Congress established a rule of rate making, as well as a principle to govern a fair return, and the disposition of the excess revenue. Section 15a provides that a level of rates be established sufficient under honest, efficient, and economical management to earn a fair return. May I call your particular attention to the requirement as to honest, efficient, and economical management? While section 15a is usually spoken of as safeguarding the rights of the corporate carriers, its purpose was also to assist in maintaining proper credit so that the transportation system might be satisfactorily operated and developed.

Congress realized that rates could not be established that would give uniform earnings to strong and weak carriers alike, and that excess earnings were bound to be realized by the strong roads. One-half of such excess is to be collected and deposited in a contingent fund to be used in the furtherance of transportation needs by making loans and in purchasing and leasing equipment to carriers. This provision recognizes the unity of the transportation machine and is to strengthen the credit of the carriers as a whole rather than to enhance the income of particular carriers.

Hence regulation has now become a dual function—first to prevent undesirable discrimination, and second, to determine general rate levels and control railroad profits. Theoretically at least the law not only protects the public from high rates, but protects the railroads from rates that are too low.

But a reasonable rate level will not encourage the investment of private capital unless there is a guarantee against financial mismanagement. These practices in the past have had a significant influence on rates, service, and credit. It is not necessary to discuss the relationship of over-capitalization to rates and service other than to point out that over-capitalization leads to impaired service through its destructive influence on the credit of the carrier. So the Act provides that a carrier must secure authority from the Commission before securities can be issued. It is usually thought that this section is to protect investors, but the regulation of security issues is also necessary to help and protect service.

The authority of the Commission was also extended to prescribe minimum rates as well as maximum. This was intended as a safeguard from rate wars which result in the destruction of revenues. Power was also given to prescribe divisions between carriers and in so doing to give due consideration to their financal needs. This was to help solve the difficulties surrounding co-existence of the weak roads and the strong roads. Under the old system, divisions were a matter of bargaining among the interested carriers, and in many cases strong carriers forced inequitable divisions upon weaker ones.

I have endeavored to show that while the primary purpose of the first legislation was to remove discrimination between shippers, it was also of immense aid to the transportation industry. Those who advocate a hands-off policy on the part of the Government and who simply repeat the slogan "let the railroads alone" forget that the effect of the greater part of legislation has been to help the railroads—if not the corporations operating them. So far as the railroad as a public utility is concerned, a study of the legislation from the first land grant down to the Transportation Act shows that it has been the policy of the Government to be helpful to the railroads even to the extent of protecting them from themselves. Therefore I think that the phrase "Help the railroads along" would be more representative of the effect of regulation.

The provisions for an adequate transportation machine involve a very difficult adjustment between private rights of the operating interests and the public interests. The operation of this law and the performance of railroads under it have not been fully co-ordinated and this has given rise to the oft-repeated phrase that the railroads are on trial. The railroads, like every other human agency, are always on trial. So long as they perform with efficiency and economy the functions for which they were created, they will continue to exist in their present or in an improved form. I am not overlooking the fact that within the past score of years 400,000 miles of hard-surfaced highways have been built in this country on which millions of automobiles and motor trucks now carry on a large portion of the transportation service that otherwise would be performed by the railroads. I think that it is not too much to say that we are at present passing through an evolution in the transportation indusry perhaps greater than from the stage-coach to the canal, or from the canal to the railroad. It is this that will tax to the utmost the constructive ability and genius of those in charge of the mechanical departments of our railroads.

The solution of the railroad problem is a matter for the people to decide. It is the duty of all of us to follow the policy indicated by them. The success of the present laws depends largely upon the attitude of the carriers themselves. They must show in practice that they realize that they are performing a public function. They must willingly agree to co-operative arrangements in order to promote the general transportation needs. And above all, they must realize their responsibility to the public in operating efficiency and must co-ordinate their administrative control, operating practices, methods of maintenance, and purchasing plans in such a way that will promote economies wherever possible. Unless this is done, the rate features of section 15a will fail either to protect the public against excessive charges or to give the carriers adequate revenues.

There are innumerable ways in which this association as such, and its members in their official capacities, can promote economy and efficiency in operation and thus carry out the policy of the Act. Some of them are as follows:

Standardization

The value of standardization of railway equipment has long been recognized by this association. This does not mean stagnation but improvement along certain well defined lines even though it does sometimes result in sacrificing some of our pet theories or designs. Wonderful progress has been made in the standardization of freight car design, construction, and repair; in fact at present we are approaching the point where, except for the older types of cars, there is no good reason for sending freight cars home for any repair short of rebuilding. And even rebuilding, in the case of damaged cars, is quite generally being done by the line responsible for the damage. There can no longer be doubt as to the feasibility or desirability of complete standardization of all general service cars leaving each railroad to provide such special equipment as the character of its local traffic may require. Complete standardization of passenger cars is not so essential, although it will bring about economies in manufacture and in carrying charges on repair parts which will result in substantial savings.

Although the use of joint roundhouses or joint terminal facilities is not uncommon, locomotives are not generally interchanged, and, so far as maintenance is concerned, standardization of locomotives is not so urgent. However, it would produce substantial economies in manufacture and result in saving in the engineering department to have standard designs as far as the service conditions will permit. Manufacturers of railway supplies have done wonders in standardization and their methods in this respect can be profitably followed.

Idle Equipment

This means not only equipment that is idle due to being unserviceable, but also equipment which for any other reason does less than a reasonable days' work each day. I think it is quite common to disregard the cost of an excessive number of locomotives standing idle either awaiting repairs or ready for service. As they are always stored directly under the eyes of the mechanical department officials, it is difficult to understand just why they should be overlooked unless the carrying charges have never been calculated.

It is somewhat different as to freight cars because they are stored at various places along the line. Unless a careful check is made the number of idle cars, even of foreign cars, may be overlooked. However, there is little difference between the per diem on a foreign car and the cost of carrying a home car. The per diem is about $1 per day and the depreciation and interest charges on the average box car will run very close to $1 per day. To pay the cost of keeping a car standing idle for one day will require the revenue earned hauling one ton of freight 100 miles, and the cost of one idle locomotive for one day equals the revenue earned hauling one ton of freight 1,200 miles. Carrying charges on the difference between 10 per cent and 17 per cent of locomotives unserviceable consumes the revenue of hauling a ton of freight 5,392,800 miles per day and approximately two billion miles per annum.

The loss on unserviceable locomotives, however, is a relatively small item in comparison with the waste of time by locomotives at terminals. The average locomotive performs about 6 hours' service out of each 24. This is partly due to lack of terminal facilities, but partly also to methods and organization at terminals. Careful investigations have repeatedly shown an average loss of from 3 to 5 hours getting locomotives to and from trains. A similar loss getting them across the cinder pit leaves a relatively small percentage of time available to make necessary repairs. Surely it should not be too much to expect that a locomotive would actually earn money 50 per cent of its time. The savings in carrying charges that would result from a more intensive use of locomotives and cars would be startling.

Budget System of Doing Work

Much has been said in favor of the budget or appropriation system in handling maintenance expenditures. It is not my purpose to discuss the advantages and disadvantages of this system, but I wish to refer to what may be called the budget system of distribution of work. One of the most valuable assets a railroad can have is a corps of steady, contented, reliable employees. They cannot be secured where it is the general practice to attempt month by month or week by week to make reduction in the payroll correspond with fluctuations in business. Of course, I know it is not possible to disregard revenue in order to keep a uniform force of employees, but with a little more foresight that should not be necessary. Year in and year out it is possible to make a very close approximation of the number of class repairs that will be required during each year to maintain equipment in good serviceable condition. It is true that we have good years and bad years, but taking one with another it is entirely feasible to calculate very closely just what will be required in the way of class repairs. If this can be divided into equal parts and the shops assigned a certain number of regular class repairs per month, there will be no increased cost in the total annual expenditure if the shops are kept working at a rate which will turn out that number per month. Under this plan it is true that during the dull months the number of locomotives in white lead will increase, but under the other plan the number in bad order will accumulate. It is cheaper and much more satisfactory to store locomotives in white lead than it is to store them in an unserviceable condition.

The big difference between the two policies is apparent when business begins to improve and there is a demand for power and at the same time for men. The forces can not be increased to correspond with the increased demand for power. The result is a large amount of penalty overtime causing more or less dissatisfaction, and the use of equipment which is not in good serviceable condition. This policy causes losses all the way along the line, first, in performing work under pressure without sufficient force or facilities; second, in operating equipment not in good condition resulting in increased repair costs and fuel costs; and third, in causing delay to traffic with resulting expense for overtime, and in many other ways.

No doubt this has all been said before in various ways, but it is also true that the results of 1923, which have been pointed to with pride so far as the movement of traffic is concerned, strongly indicate the need for saying it again. Maintenance of equipment expenditures during 1923 were $1,465,405,904, or about one dollar out of every four earned by the railroads and expenditures for new equipment during the same period amounted to about $690,857,266. The members of this association therefore were responsible for a total expenditure of considerably over $2,000,000,000. Increased capital expenditures require increased revenues.

I have no criticism to offer of the results in the way of handling traffic for the year 1923, but we may as well face the facts. While there was a tremendous increase in cars loaded over 1918, there was but a 2 per cent increase in revenue ton-miles, and to accomplish this we had 9 per cent increase in tractive power, 32.9 per cent increase in maintenance expenditures, and 65 per cent increase in capital expenditures. When the capital expenditures and the operating expenses increase in greater ratio than the increase in revenue ton-miles or increase in revenues, we are headed toward either increased rates or red figures in the ledger.

This brief review of the laws relating to transportation has been given because the members of this association are largely responsible for efficiency and economy in the maintenance of equipment and to show the importance of the most complete co-operation in the interest of operating efficiency if the railroads are to continue to enjoy the benefits of existing laws.

Summing up what I have said, the big job ahead of the members of this association is to see what can be done to eliminate losses all along the line. I appreciate the difficulty of improving terminal facilities to avoid terminal delays, but it can and should be done. I realize it costs money to adopt improved methods and put in modern machinery but to reduce maintenance costs few boards of directors would be so unbusinesslike as to refuse to appropriate the necessary money for improvements when it could be shown that the net return could be thereby increased. One of the things for which I think the Mechanical Department can rightfully be criticised is that you are not aggressive enough in selling your good ideas to the management. Develop your plans, calculate the saving which will result, show the management that in asking for necessary funds you are working in their interest and then work for the adoption of what you know to be right.

With adequate facilities and the support and cooperation of the management the members of this association can be relied upon to provide the necessary equipment to meet the transportation needs.

Passenger Train Handling

A Paper Presented by the Central Air Brake Club at the Air Brake Association Convention.

The question of passenger trains being on time and smoothly handled, is receiving much consideration, because of competition. The public has been educated to expect high speed, safety and luxuries in the way of service, that were not formerly demanded. As a result, they are critical if trains are delayed or are not handled smoothly. The influence these dissatisfied passengers have on others contemplating a trip, cannot be discounted. Therefore, the question of keeping trains on time and handling them smoothly, is not only a question of sentiment and pride, but also, in reality, a question of dollars and cents.

The fundamental cause of shocks to trains is a sudden change of slack, either in or out, and is produced by a rapid change of velocity between the various units comprising the train. The degree of severity of the shock depends upon the rate at which the change in velocity takes place, this being materially influenced by the weight and length of the train.

The direct cause of shocks are starting quickly, taking slack harshly or restarting quickly after taking slack. The action of the brakes in changing the slack will be the most severe at low speeds, therefore, make any brake application suit the speed—being careful to avoid heavy brake applications at slow speed.

It is desirable to avoid a change in the position of the throttle and the use of the air brakes at the same time. This is important if the action of either will change the train slack in the same direction. Under such condition the effect would be intensified if both were used at the same time. Do not open the throttle until all brakes have had time to release. For slow speed stops, do not shut off and immediately apply the brakes. Either shut off gradually a few seconds previously, according to conditions, or apply the brakes to a proper degree and later reduce the throttle gradually until "shut off."

A few seconds of time allowance for the effect of the action of the throttle, another between the initial and subsequent reductions is of such vital importance in the operation of long passenger trains, that the time element cannot be ignored, more especially on long trains and slow speed stops.

Rear end cars (observation and sleepers, braked at 75 per cent on 50 pounds cylinder pressure equivalent 90 per cent on 60 pounds) seldom lose much of their maximum retarding effect, because they are not load cars. Day coaches are semi-load cars while baggage, mail and express cars just ahead, although braking 75 per cent when empty, are usually loaded so that the average retardation for them when operated in trains is around 45 to 55 per cent of the total load. Forward of these is the locomotive varying from 35 to 41 per cent in brake force in proportion to the working load. From the above it will be seen that the modern passenger train running forward will stretch after all brakes are applied and stretch harder as the brake force is increased. The opposite is true of a backing train, after all brakes are applied the train bunches and remains so until the brakes are released.

Brake Effect From the Brake Pipe Reduction

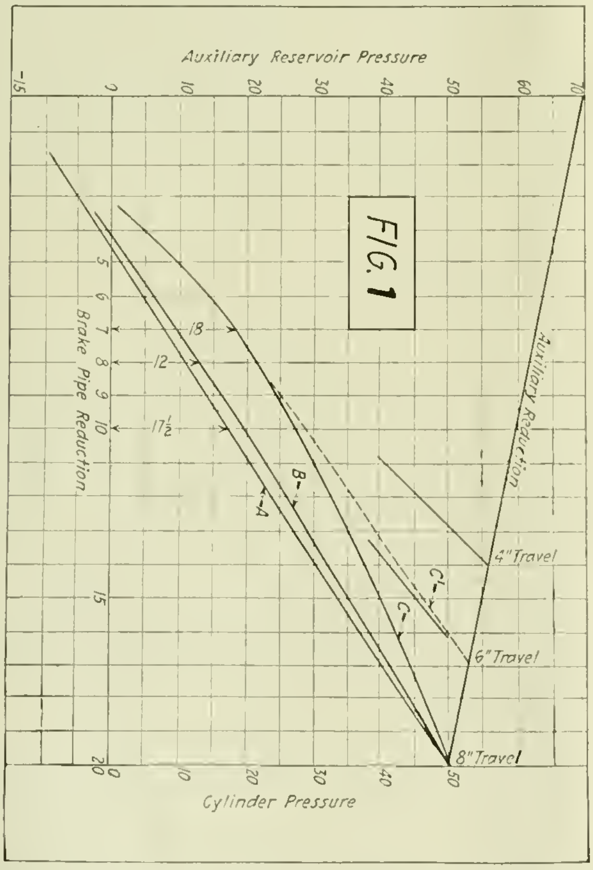
The brakes nearest to the point in the train where the reduction is started, are the first to begin to apply. With a train running forward, and the brake pipe reduction started from the head end, the tendency is to start bunching. After the brake pipe reduction is effective on the rear, the train stretches again.

If the train is backing and the back-up men are controlling, the rear brakes start to apply first, which would tend to bunch the train beginning at the rear, therefore, a very moderate use of steam by the engineer to keep the slack in, until he feels the brake begin to hold, will materially assist in producing a smooth stop. Any engineer who complains of having had his head bumped against the cab backboard, when the back-up man used the brake, should think over the above item.

This is equally true if the engineman stops the backing train. Do not "shut off" entirely until the reduction has been sufficient to have all brakes applied throughout the train. Keeping the locomotive brake released at this time assists materially.

The automatic brake is based on piston travel. Very few actually realize what this means. Many cases of rough handling can be traced to short piston travel, thus reducing the inability to develop a low cylinder pressure for a reduction of 6 to 7 pounds.

It is true that many of the older forms of passenger brakes have a great deal of deflection, which causes the



piston travel to elongate excessively as the cylinder pressure is increased, primarily due to high total leverage and weak members. Added to this, is an increase of 1½ to 2½ inches difference between full standing and running travel, due to trucks settling.

Since the slack adjusters gradually take up a great portion of this elongation, 32 to 40 operations for 1 inch take up, the standing travel is finally shorter. There is practically no difference between the standing and running piston travel on light applications. Therefore, on such vehicles the initial travel is around 4 to 4½ inches, becomes longer as the brake force is increased, and after all deflection and settling of trucks on a full application running, the piston travel approaches 8 inches. Small cylinder volume results in much too high cylinder pressure for light reductions.

So long as cars were light and trains were short, the above conditions did not interfere with train handling to any great extent, but with long heavy trains it has become quite a serious matter.

The modern clasp brake has about ½ inch difference between standing and running piston travel, very little deflection and longer piston travel for the initial reduction, with a corresponding lower pressure at this moment. Clasp brake cars should be adjusted to not less than 7½ inches, standing travel, with a full service brake application. Roads doing this are getting very good results. Some roads are adjusting the other types of foundation brakes at 7½ inches standing travel also, thereby obtaining smoother brake operation. One property, which has only the low hung, single shoe, six wheel trucks, make it a practice to start the trains with 7½ inches standing travel and let them out at one point on the line on coast trains, about half way between the extreme terminals, thus obtaining better results.

Fig. 1 is illustrative of what is desired and what frequently occurs. Line "A" represents the desired cylinder pressure per pound of brake pipe reduction. Line "B" practically represents that which occurs with a modern clasp brake, while line "C" and "C'" shows the occurrence on the cars with the least desirable foundation brake condition.

With such brake adjustments as shown on line "C," long trains cannot be regularly and smoothly handled.

Graduated Release

There are two types of Graduated Release Brakes in use for steam road service known as L. N. and U. C. When an experienced air brake man thinks over the flexibility of the straight air brake, with its ability to be "graduated off," to produce less declaration, he does not wonder that graduated release was incorporated in the automatic brake.

In the days of lighter trains and few cars, the one application method of stopping passenger trains with the automatic brakes, was common practice. In conjunction with this was the pre-release, or releasing just sufficiently before the stop so that only a light pressure was present in the brake cylinders as the train stopped. This allowed the tilting trucks to right themselves and avoided the backward lurch at the stop.

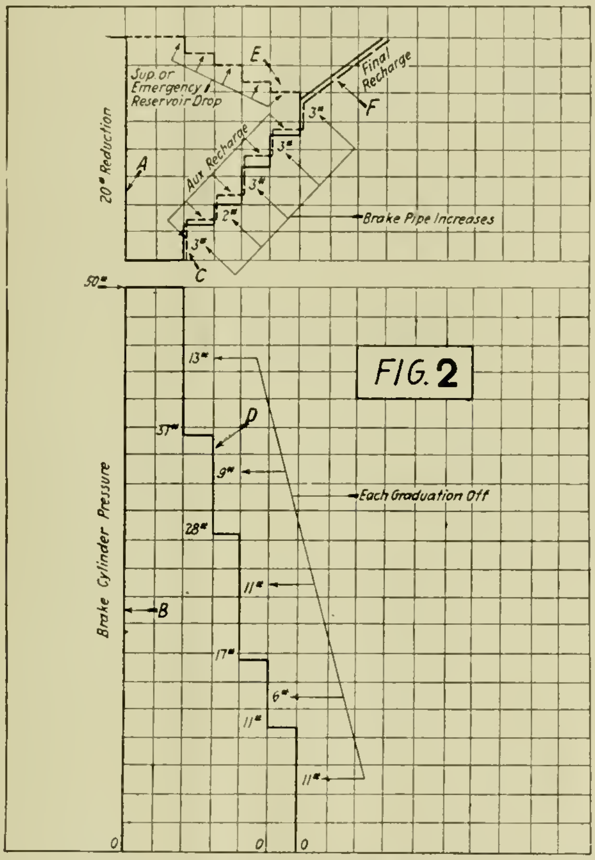
Later on as trains increased in length it became the custom to require the two application method of stopping them. By this method the brakes were intended to be used the heaviest during an application which served to reduce the speed quite rapidly until it was under complete control near the stopping place, where all the brakes were to be entirely released, and reapplied later and much lighter for the final stop. This method was considered the most practical under the existing conditions for the following reasons:

First. With ordinary automatic brakes it has been considered questionable to release just before a dead stop on trains of 9 cars or more, due to the liability of breaking the train in two, principally due to the delay in obtaining a release of the rear brakes.

Second. As considerable wheel sliding occurred during the latter part of a one application stop, the two application method is intended to reduce this trouble by producing the greatest retardation during the use of the first application—then, after its release the second and much lighter application is to be so used that a light cylinder pressure will be present at the finish of the stop.

Third. It was considered impractical to require long trains to be stopped accurately with one application (several reductions without having the highest cylinder pressure present at the finish of the stop, because the engineman corrected his judgment of speed and distan by graduating the brakes "on" only.

The two application method consumes considerable more time, and requires more stopping distance than the one application stop; particularly so, if done correctly and within the bounds of the above requirements and intention. It also requires the engineer to control the train slack twice instead of once, as with the one application method. Where long trains are stopped by



the above methods they are usually hard to start, due to the train being stretched considerably.

Three things are required: Smoothness, accuracy and making time.

The one application, "graduated off" stop requires less distance than the two application stop, and along with it, less time. It assists in making schedule time. This is demonstrated in suburban and interrurban service. Smoother stops are accomplished because the train slack adjustment is usually made only once and at the beginning of the stop, and while the speed is highest; also, because the brakes are coming off near the end of the stop. The engineer is enabled to correct his judgment of speed and distance after he has used the brakes sufficiently strong to be sure he is inside the stopping distance by enabling him to "graduate off" to place the train at the desired location. This avoids an entire release and reapplication, which under some speeds and distance to final stopping point, causes rough handling with the two application method.

Where the brakes are graduated off properly, long trains are more easily started because the train stetch is reduced and draft gears release to nominal position while the train is moving. The ability is present to more surely move all triple valves or equalizing portions of brake equipments to release position (therefore less stuck brakes) because graduated release, quick recharge brakes require an increase of brake pipe pressure only. This raise can be made quite rapid.

The auxiliary reservoir recharge is taken care of by the air pressure from the supplementary or emergency reservoirs until the brake is entirely released. This avoids a drain on the brake pipe pressure while the release is being accomplishd; also permitting several reapplications of the brake in quick succession without materially depleting the system. After the quick recharge feature has been entirely absorbed the final finish of the recharge of all reservoirs comes from the locomotive through the brake pipe.

Fig. 2 illustrates the action of the pressures as caught by gauges on an individual graduated release brake. Line A represents the brake pipe reduction. Line B illustrates the resultant brake cylinder pressure. Line C solid and dotted show the increases of brake pipe and auxiliary pressures while graduating off. Line D indicates the graduated release of cylinder pressure. Line E corresponds to the supplementary or emergency reservoir drop while it is recharging the auxiliary reservoir. Line at F represent the final recharge of reservoirs from the brake pipe.

Figs. 3 and 4 are sections of two recorder charts taken from the forward and rear portion of a 14 car L. N. equipped train with 22 brakes, 8 cars having double brakes. All equipment was first operated as P. M., supplementaries being cut out. (See Fig. 3).

Tests No. 1 and 3 are running position releases. Tests No. 2 and 4 show release position use for a limited length of time. Observe the slow rise of brake pipe pressure at the rear end of train, on account of the drain by the 22 auxiliary reservoirs.

Compare these with the occurrence on Fig. 4 in which the supplementaries are cut in on the first four of these tests.

Tests No. 5 shows running position release. Tests No. 6 shows release position, then running position the balance of the time.

Tests No. 7 shows running position, lap, running position, step ups.

Tests No. 8 shows running position, three releases and three reapplications in quick succession. Note the rapid and near equal rise of the rear and forward brake pipe pressure on each release. Test No. 9 shows supplementaries cut out again and three similar releases and reapplications made. This time the brake valve was used in release position only until the forward brake piston returned into the cylinder when reapplication was made. Note how impossible it was to drive the air through the brake pipe with any rapid result, due to absorption by the numerous auxiliary reservoirs.

Usually about 50 seconds or less is consumed in making the stop while not longer than 15 to 20 seconds of this is used while the brakes are being graduated off. The average time for the long train two-application stop requires from 60 to 75 seconds, if done as intended.

Two positions of the brake valve are used to increase the brake pipe pressure while graduating off, the release position and the running position.

The release position furnishes a rapid rise, generally used for the first graduations off on long trains, for recharging on grades or for releasing the last graduation where it is desired to reduce the cylinder pressure quickly. The running position supplies a smaller but effective opening for subsequent graduation on long trains and all "graduations off" on shorter trains.

Frequently graduated release trains have a few P. M. equipment brakes placed in the service. Many of you are desirous of knowing where the limit should be placed on having good graduated release work accomplished. It has been shown that if three-fourths of the train is graduated release equipment, good graduated release operation can be performed. When P.M. equipment cars are in graduated release operated trains they release entirely when the first graduation off is made. The others come off as more release is desired.

A good graduated release engineer will pay no attention to a few P.M. cars, but governs himself by way the train decelerates after the first graduation off.

When spot stops are made, usually the train should be handled that all brakes are released and the train is approaching at 5 or 6 miles per hour, two or three engine lengths from the stopping point; and with the locomotive shut off in time to allow the slack to adjust itself. Then a light application should be made early enough to get the brake shoes against the wheels before the final one or two small reductions needed to complete the stop are required.

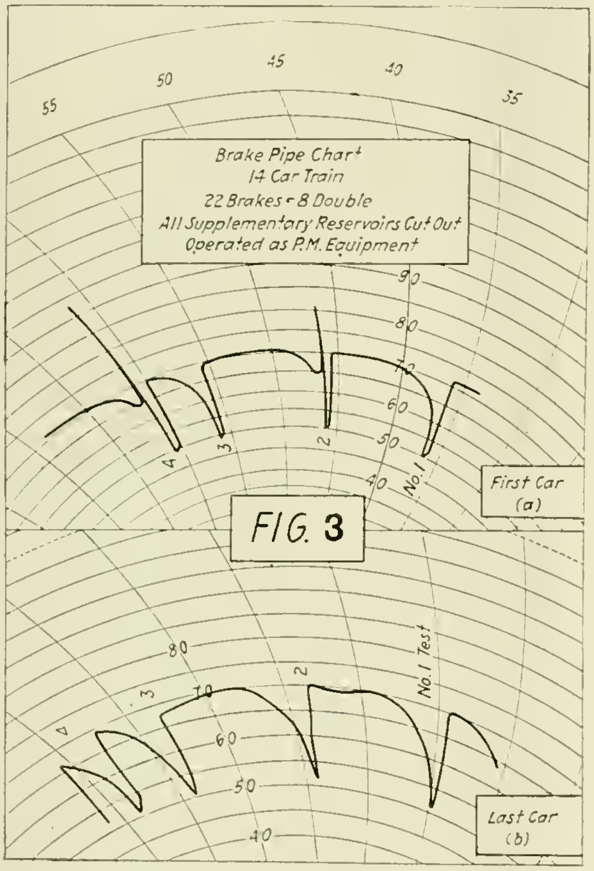


FIG. 3

Where spot stops are not made smooth with the above intended method, it is usually found that either the equipment produces more braking force per pound of brake pipe reduction than intended, or the engineman delays the initial reduction too late and then crowds the brake on too rapidly for the speed to keep from going by.

Others make drag up stops and with the slack all out, they shut off the throttle and at the same instant, apply the brakes. Some of the members of this Club are advocating and are producing good water stops with long trains, by graduating off and having the entire train brakes released before it has reduced in speed below 7 or 8 miles per hour three or four car lengths away from the spot. During this period they "lap" the independent brake valve and hold 10 or 15 lbs. in the locomotive brake cylinders. They then graduate the independent brake "off" or "on" to the stop. This method changes the slack of train easy. They now have the slack "in" and if a light service application is necessary at the stop, the train just bunches a little harder.

This method should positively not be used at slow speed as to do so would cause a bad run in of slack and produce rough handling. This Committee believes that advocates of the above are being driven to the practice mentioned because of adverse air brake conditions that should be corrected.

Mountain Grade Braking

Retaining valves should be used on graduated release trains, the same as P.M. equipment trains, whenever the brakes cannot be recharged to 80 lbs. When operating with retaining valves be sure that the application is sufficient to insure a release, so that the train is retarded by retaining valves and not by sticking brakes. Graduated release must not be used when retaining valves are in operation. Where retaining valves are not cut in and graduated release is depended upon, not more than one release graduation should be used between complete recharges. Use release position of the brake valve when recharging, and follow with a "kick-off."

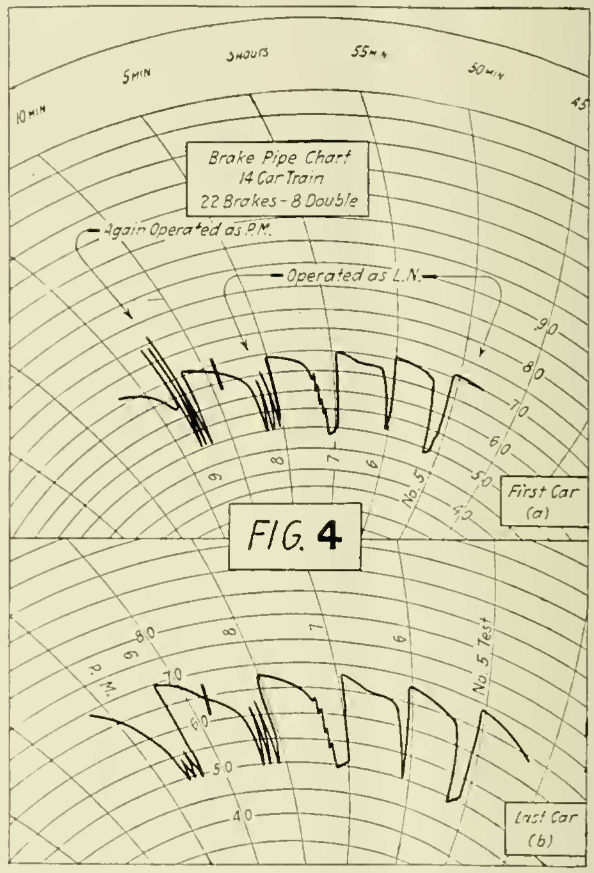


FIG. 4

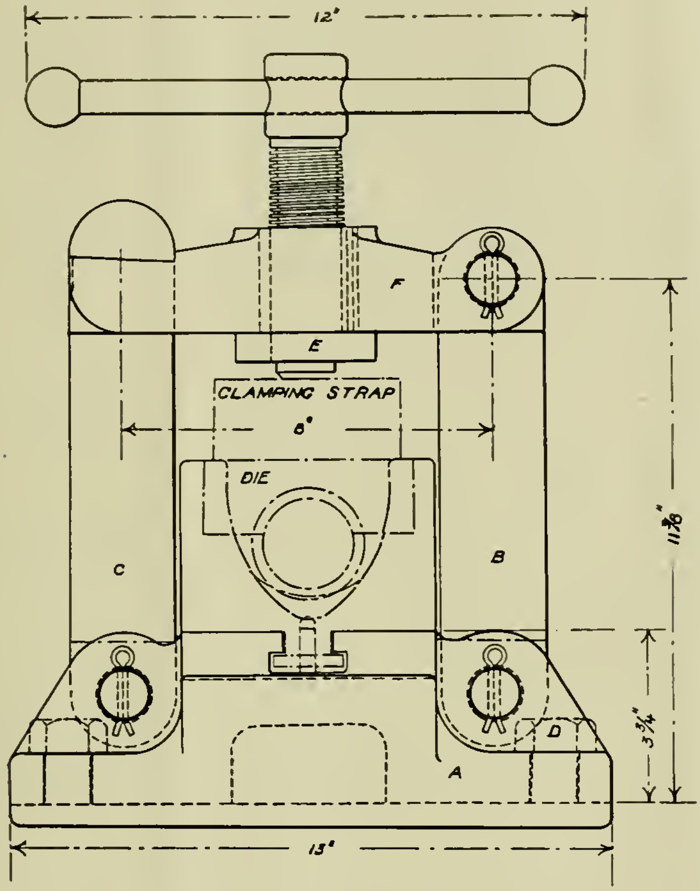
Where trouble is experienced with brakes sticking on graduated release equipment after locomotives are changed, or switch engines are used to change the make-up of train, this is primarily caused by a difference of brake pipe pressure adjustment on the different locomotives. The locomotive not experiencing this trouble, having the higher pressure, possibly too much, while the one having the trouble has the lower pressure, possibly below the authorized amount.

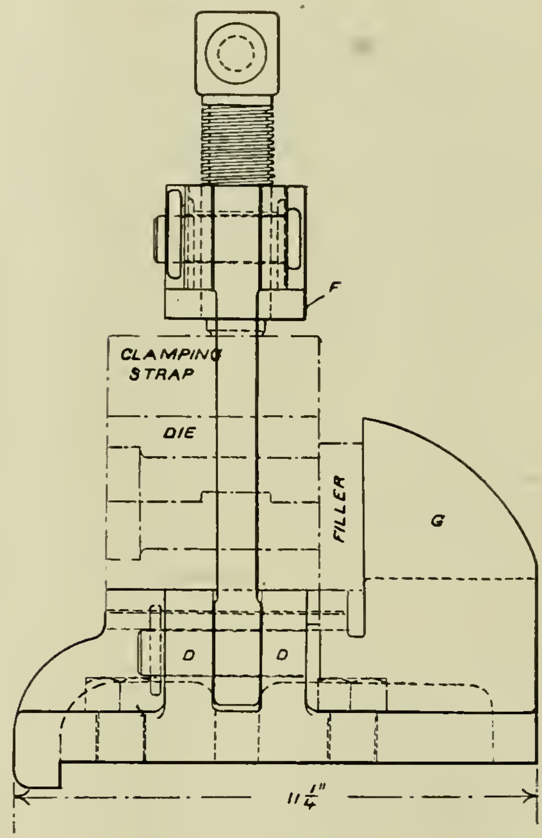
A good practice to follow when changing engines is to leave the brakes applied by the delivering engine after stopping. The receiving engine releases them and when test of brakes is made, it will eliminate any trouble due to a slight difference of air pressures between the two locomotives.

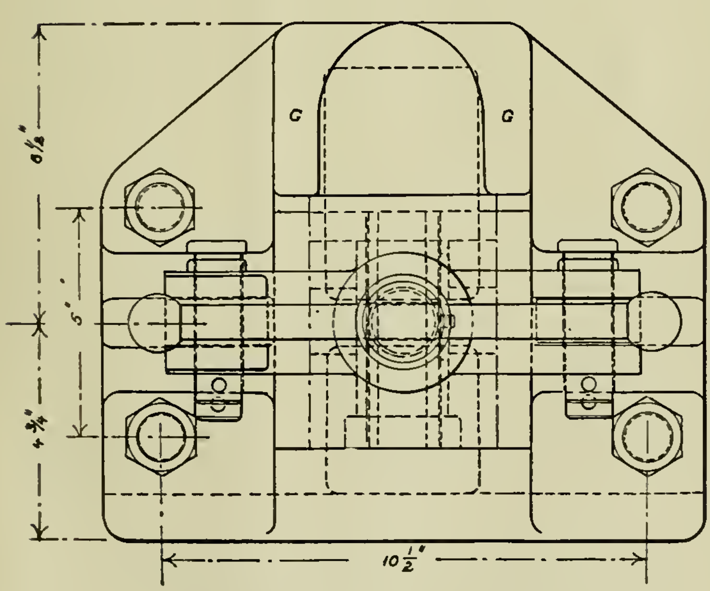
Shop Kink by John Mitchell

Tool for Putting Flanged Collars on Copper Pipe

The tool shown herewith is one that is used for putting flanged collars on copper pipe and thus does away with the common brazed and ground joint that is used on in-







Vise Arrangement for Copper Pipe Flanging Device

jector work and other places where copper pipe is used.

The work is done in a vise attached to a bench. The form of vise is one which somewhat resembles a pipe vise. It consists of a base *A* having jaws *DD* on either side, to which the links *B* and *C* are pivotted on 1 in. diameter pins. These links are made of 7/8 in. by 2 1/4 in. steel and the link *B* is pivotted at its upper end to a cross bar *E* which carries the tightening screw and lever. At the left hand end this cross bar is held by two lugs or shoulders on the link *C*. It will be seen from the assembly engraving that if the cross bar be dropped down a little the link *C* can be swung out of the way to the left and then the cross bar and the link *B* can be swung to the right and the base of the vise left clear above for the placing or removal of work.

The cross bar is fitted with a brass bushing *F* cut with 6 acme threads to the inch for the tightening screw which is 1 1/2 in. in diameter. At the back of the base there is an upwardly projecting pair of horns *G* which serve as holders to keep the pipe, being operated upon, fairly in line.

The flanging dies are made of forged steel finished all over and case hardened, one being required for each size of pipe to be flanged, and these are divided into two groups as far as longitudinal dimensions are concerned. In this, group A is intended for pipe varying from 2 1/4 in. to 3 1/4 in. in outside diameter and group B for pipe varying from 1 1/4 in. to 2 in. in outside diameter.

The engravings give the common dimensions of each group and in the following tables the variable dimensions are given:

DIMENSIONS OF GROUP A DIES

Copper pipe size outside Diameter, inches	Dimension in inches A	B	C	D	E	F
3¼	3¼	3⅞	5½	2½	13/16	5½
3	3	3½	5¼	2⅜	11/16	5½
2¾	2¾	3¼	5	2¼	11/16	5
2½	2½	3	4¾	2⅛	11/16	4¾
2¼	2¼	2 13/16	4½	2	¾	4½

DIMENSIONS OF GROUP B DIES

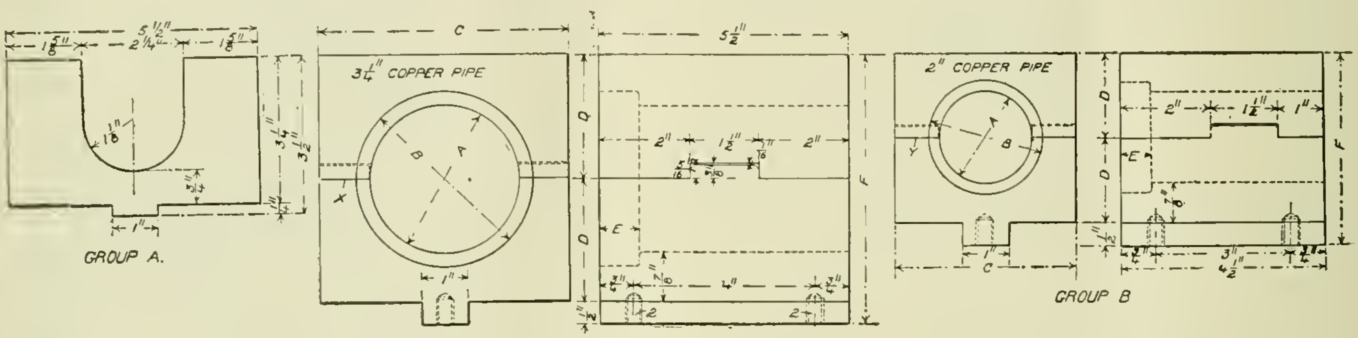
Copper pipe size outside Diameter, inches	Dimension in inches A	B	C	D	E	F
2	2	2 7/16	4¼	1⅞	⅝	4¼
1¾	1¾	2 3/16	4	1¾	⅝	4
1½	1½	1⅞	3¾	1⅝	9/16	3¾
1¼	1¼	1 9/16	3½	1½	½	3½

When boring out the hole *A* and the counter bore *B* of the *A* group, a shim 1/32 in. thick is placed between the two dies at X. And, when boring out the same hole and counterbore on the group *B* dies, the shim at Y is made 1/32 in. thick for the die for 2 in. pipe and 1/64 in. thick for each of the other three.

are used for the operation of which two sizes of drift pins suffice.

The form of these expanders is shown in the engraving. They are cut into four or six segments according to the size of pipe for which they are intended, and they are split with a cutter .094 in. thick. They are held together in the closed position by a rubber band set in the groove as indicated and the corners of the segments are filed away at *X* as indicated, by which a small groove is formed for the guidance of the drift pin. The expander and the drift pin are made of from .70 to .80 carbon steel, heat treated and each segment is stamped with a stencil figure denoting the size of pipe on which it is to be used. The bore in the expander for the reception of the drift pin is tapered one in 10 in order to fit the same.

In addition to the expander there is a solid guide ring made of tool steel, which has an outside diameter 1/32 in. less than that of the counterbore *B* in the dies. This slips into the counterbore ahead of the shoulder on the

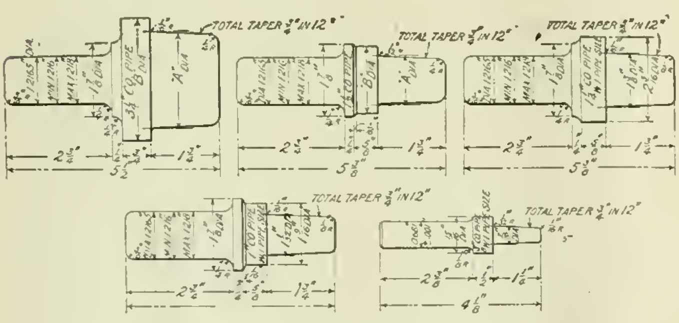


Copper Pipe Flanging Dies

The size of pipe for which the dies are intended is stamped on the face of each section, as indicated in the engraving of the upper section.

These shims give just enough of separation to the two parts to clamp the pipe firmly when they are brought together in the vise.

The filler is 1 in. thick and is placed back of the dies in the vise, as indicated when flanging 2¼ in. or smaller



Pneumatic Hammer Dies for Copper Pipe Flanges

sizes of pipe and serves both to adjust the dies and steady the pipe.

There is a clamping strap measuring 1¾ in. by 3½ in. by 4½ in. which is laid across the top of the upper die and serves as a bearing piece to take the direct thrust of the screw.

In order to do the work of flanging two sets of tools are required; one for first expanding the pipe and the other for flanging afterwards.

As the method is used, not only on the nine sizes of copper pipe indicated on the preceding tables but on 1 in. wrought iron pipe sizes as well, ten sizes of expanders

expander and against the end of the pipe and serves a purpose that will be explained later.

The drift pin is a simple tapered pin, with a taper of

EXPANDER DIMENSIONS

Pipe Size Dia. of Tube	Turning Dimensions in Inches A	B	C	D	E	F	G	H	I	No. of Segments
3¼	3 1/16	31/32	2 13/32	3½	1	5/16	1 15/16	2⅝	5/32	6
3	2 13/16	31/32	2 7/32	3⅛	⅞	5/16	1 13/16	2 7/16	5/32	6
2¾	2 9/16	27/32	2 7/32	3	13/16	¼	1 11/16	2 3/16	5/32	6
2½	2 5/16	27/32	1 31/32	2¾	13/16	¼	1 11/16	1 15/16	5/32	6
2¼	2 1/16	27/32	1 31/32	2½	⅞	¼	1¾	1 31/32	5/32	6
2	1 13/16	19/32	1 15/32	2¼	¾	¼	1⅝	1½	⅛	4
1¾	1 9/16	19/32	1 7/32	2	¾	¼	1⅝	1¼	⅛	4
1½	1 5/16	19/32	1 3/32	1¾	⅝	¼	1½	1 7/32	⅛	4
1¼" Co. P. Size, 1" W. I. P. Size.	1 1/16	19/32	31/32	1½	9/16	¼	1 7/16	27/32	⅛	4

W. I. Pipe Sizes	Turning Dimensions in Inches A	B	C	D	E	F	G	H	I	No. of Segments
1¼	1 7/16	19/32	1 3/32	1⅞	⅞	¼	1¾	1 7/32	5/32	4

GUIDE RING DIMENSIONS

Co. Pipe Sizes O. S. Dia. of Tube	Finished Dimensions in Inches P	K	M	N	O
3¼	3 9/32	3 31/32	3	3/16	5/16
3	3 1/32	3 15/32	2¾	3/16	5/16
2¾	2 25/32	3 7/32	2½	3/16	¼
2½	2 17/32	2 31/32	2¼	3/16	¼
2¼	2 9/32	2 25/32	2	3/16	¼
2	2 1/32	2 13/32	1¾	3/16	¼
1¾	1 25/32	2 5/32	1½	3/16	¼
1½	1 17/32	1 31/32	1¼	5/32	3/16
1¼" Co. P. Size, 1" W. I. P. Size	1 5/16	1 17/32	1	⅛	3/16

W. I. Pipe Sizes	Finished Dimensions in Inches P	K	M	N	O
1¼	1 11/16	2 7/32	1⅜	3/16	¼

one in ten and with a ring in a hole in its small end that prevents it from falling out of the expander when it is loosened and thus all parts are held together for rapid adjustment and use. The rubber band holding the segments together and the ring preventing the pin from falling out.

The several dimensions of the expander rubber band, guide ring and drift pin are given in the foregoing tables.

For the drift pins the dimensions for the copper pipe sizes ranging from 2¼ in. to 3¼ in. inclusive are A = 17/32 in.; D = 1¼ in. and L = 10¾ in. For copper pipe sizes ranging from 1¼ in. to 2 in. and the 1 in. and 1½ in. wrought iron pipe, the dimensions are A = 5/16 in.; D = 15/16 in. and L = 9 in.

The flanging tools which are used in a pneumatic hammer are shown in Nos. 1 to 5 inclusive.

No. 1 is intended for use on pipes ranging from 1¾ in. to 3¼ in. outside diameter inclusive, the only variations in dimensions being those marked A and B. The tools represented by No. 2 are for pipes of 1¼ in., and 1½ in. outside diameter. Again the only variation in dimensions being for those marked A and B. These variations are all set forth in the following table:

No.	Outside Diam. of Pipe, Inches	Dimensions in Inches A	B
1	3¼	2 31/32	3 13/16
1	3	2 23/32	3 7/16
1	2¾	2 15/32	3 3/16
1	2½	2 7/32	2 13/16
1	2¼	1 31/32	2¾
1	2	1 23/32	2⅜
1	1¾	1 15/32	2⅛
2	1½	1 7/32	1 13/16
2	1¼	31/32	1½

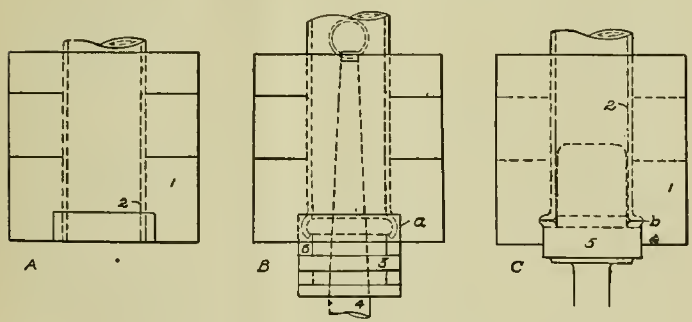
No. 3 is for 1¼ in. copper pipe; No. 4 for 1 in. and No. 5 for ⅜ in. copper pipe all of wrought iron pipe size.

All of these flanging tools are made of tool steel having a carbon content of from 0.80 to 0.90 per cent and are heat treated. The size of pipe for which they are intended to be used are stamped on the main bars with a stencil having letters ⅛ in. high.

Finally in regard to the method of using the tools and doing the flanging.

The process is shown by the three illustrations *A*, *B* and *C*.

A shows the flanging die[1] with the pipe[2] in place. This



The Three Stages in the Flanging of Copper Pipes

is the first operation. The pipe is annealed and then clamped in the die with its end flush with the face of the same in order to leave sufficient material projecting from the clamping portion for the gather.

The second operation is shown at *B* where the pipe 2 is still held in the clamping portion of the flanging die 1, with the expanding tool 3, in place with the drift pin 4 set in to expand the pipe at *a*, and guide ring 6 entering the counterbore of the flanging die and holding the whole in alinement.

The third operation is shown by *C* where the pipe is still held in the flanging dies, and the hammer die or flanging tool 5 has been driven down so as to form the flange at *b* as desired.

A coppersmith will readily see that flanging can be done with great rapidity with such a set of tools. As a matter of fact collars for 2½ in. outside diameter pipe have been formed in a minute and a half from start to finish, leaving the collar in such shape as to require no subsequent machining in order to make a tight joint. When this is compared with the time required to turn a brass joint, braze it to the pipe and grind it in place the time saved is very apparent.

Imperial Government Railways of Japan Place $1,500,000 Orders for Electrical Equipment

As a part of their extensive program of electrification, the Imperial Government Railways of Japan have placed orders for electrical equipment amounting to $1,500,000 with the Westinghouse Electric and Manufacturing Company. The order includes six 75-ton, 1,200 hp. locomotives and two 102½ ton, 1,800 hp. locomotives for operation at 1,500 volts. The eight locomotives are to be placed in passenger service on the electrified section of the Imperial Railways' main line out of Tokyo.

Ten 2000 kw. rotary converters and ten transformers for operation with the converters are also called for under the order. Both the converters and transformers are designed to operate at 1500 volts but are so arranged that they can be temporarily operated at 600 volts. Each of the converters consists of two 1000 kw. converters mounted on the same bedplate. Four of them will be used in the Shiodome substation of the Imperial Railways, three in the Idamachi substation, and three in the Ueno substation.

In a satement made just after the order was received, I. F. Baker, Manager of the Westinghouse Electric International Company in Japan, said, "This order is the result of several years study with the Imperial Government Railways, during which a careful comparison was made between Westinghouse equipment and that of important European competing companies and is an indication of the excellence of American designed electrical apparatus."

Locomotives

The Chicago, Rock Island & Pacific Railway has ordered one Pacific type locomotive from the American Locomotive Company.

The Lehigh Valley Railroad contemplates buying 20 locomotive tenders of 12,000 gal. capacity.

The West India Sugar Company has ordered one Mogul type locomotive for the Central Palma, Cuba, from the Baldwin Locomotive Works.

The Ulen Contracting Company, New York, N. Y., has ordered one Mikado type locomotive from the American Locomotive Company for the Villazon Atocha Railway, So. America.

The Japanese Government Railways has ordered through Takat & Company, New York, N. Y., 8 electric locomotives, 2-93-ton electric locomotives and 6-70-ton electric locomotives. The locomotives will be built by the Baldwin Locomotive Works and the Westinghouse Electric & Manufacturing Co.

The Colombian Government has ordered from the American Locomotive Company 2 Mikado type locomotives for the Ferrocarril del Pacifico.

The New York Central Railroad is inquiring for 30 Pacific type locomotives and 25, 0-8-0 type switching locomotives.

The Boston & Albany Railroad has ordered 4 switches from the American Locomotive Company.

The Detroit, Toledo & Ironton Railroad will commence the construction of its first electric locomotive in its own shops at River Rouge on about July 15.

The New York Central Railroad is inquiring for prices on 2 to 30 electric locomotives.

Passenger Cars

The New York, Chicago & St. Louis Railroad has ordered one private car from the Pullman Company.

The New York Central Railroad has ordered 28 horse cars 70-ft. long from the Merchants Dispatch Transportation Company.

The Rutland Railroad is inquiring for one 70-ft. combination passenger and mail car.

The Canadian National Railways has ordered 6 all-steel combination mail and express cars from the American Car & Foundry Company.

The Charlotte Harbor & Northern Railway is inquiring for 2 all-steel coaches and one all-steel combination mail and baggage car.

The Dansville & Mount Morris Railroad has ordered one 50-passenger twin engine motor car from the Edward Railway Motor Car Company.

The Delaware, Lackawanna & Western Railroad has ordered 50 steel surburban coaches from the Pullman Company and 10 combination passenger and baggage cars from the Bethlehem Shipbuilding Corporation.

The Wabash Railway has placed an order for 20 passenger cars with the American Car & Foundry Company, consisting of 10 baggage cars, 5 chair cars, 2 diners and 3 passenger-baggage cars.

The Pennsylvania Railroad has ordered one model 55 gasoline car from the J. G. Brill Co., Philadelphia, Pa.

The Illinois Central Railroad is inquiring for 130 motor cars and 130 trailers for suburban passenger service.

The Central Railway of Brazil has ordered 6 first class passenger cars from the American Car & Foundry Company.

The Louisianna & Arkansas Railroad is inquiring for one baggage-mail car to have a 15-ft. mail section.

The Reading Company is inquiring for 70 suburban coaches, 10 to 20 suburban combination cars and 10 baggage cars.

The Temiskaming & Northern Ontario Railway has ordered one storage battery passenger car from the International Equipment Company.

The Richmond Fredericksburg & Potomac Railway has placed orders for 3 express cars and 2 coaches with the American Car & Foundry Company.

The Baltimore & Ohio Railroad is inquiring for 80 suburban coaches.

Freight Cars

The New York Central Railroad is inquiring for 60 express refrigerator cars of 35 tons capacity.

The Carnegie Steel Company is inquiring for 10 steel gondola cars of 70 ton capacity.

The Lehigh & New England Railroad is inquiring for 200 box cars.

The San Antonia & Aransas Pass Railroad has ordered 500 refrigerator cars from the Orange Car & Steel Company.

The National Railways of Mexico, have given a contract to Samuel Vauclain, president of the Baldwin Locomotive Works, for about 300 freight and passenger cars.

The Chilean State Railways are inquiring for 100 flat cars for use on the Arica La Paz Railway.

The Lehigh & New England Railroad is asking for bids on the repair of 300 hopper cars of 50 tons capacity.

The Denver & Rio Grande Western Railroad has ordered 32 automobile cars from the Pennsylvania Car Company.

The Central of Brazil has ordered 50 refrigerator cars from the Middletown Car Company.

The Seaboard Air Line Railway is inquiring for 10 caboose cars.

The Western Fruit Express is inquiring for 1,000 underframes.

The Sandy Valley & Elkhorn Railway has given a contract for the repair of 1,000 all-steel hopper cars to the Youngstown Steel Car Company.

The Great Northern Railway is inquiring for 100 underframes for automobile cars.

The Detroit Edison Company has ordered 20 hopper cars of 50 tons capacity from the Pressed Steel Car Company.

The Louisianna & Arkansas Railway is inquiring for one baggage and mail car.

The Delaware, Lackawanna & Western Railroad has ordered 40 caboose cars from the Mt. Vernon Car Manufacturing Company.

The Chicago, Rock Island & Pacific Railway is inquiring for repairs to 146 dump cars.

The Florida East Coast Railway has ordered 100 ballast cars from the Rodger Ballast Car Company.

The Georgia & Florida Railway is inquiring for bids for the rebuilding of 85-40-ton box cars.

The Magnolia Petroleum Company has ordered 50 insulated tank cars of 10,000 gal. capacity from the American Car & Foundry Company.

The Carnegie Steel Company has ordered 30 hopper cars' bodies from the Warren Steel Car Company.

The Missouri Pacific Railroad is inquiring for 1,000 40-ton auto box cars and for 1,500 refrigerator cars.

The Central of Vermont Railway has ordered 12 underframes for caboose cars from the American Car & Foundry Company.

The Mexican Petroleum Company has ordered 25 tank cars of 8,000 gal. capacity for carrying gasoline from the American Car & Foundry Company.

The American Smelting & Refining Company has ordered 15 gondola cars from the Pressed Steel Car Company.

The Cairo Truman & Southern Railroad is in the market for 50 logging cars.

The Braden Copper Company, New York, N. Y., is inquiring for 12 tank cars of 4,000 gal. capacity and 12 tank cars of 10,000 gal. capacity, for export to Chile.

The Algoma Central & Hudson Bay Railway has placed an order for 50 ballast cars with the Canadian Car & Foundry Company.

The Chesapeake & Ohio Railway has ordered 100 steel underframes caboose cars from the Standard Steel Car Company.

The Swift & Company is inquiring for 100 underframes.

Building and Structures

The Atchison Topeka & Santa Fe Railway is reported to be planning for the construction of a five-stall extension to its roundhouse at La Junta, Colo., at an estimated cost of $50,000.

The Boston & Albany Railroad has awarded a contract for the construction of a locomotive pit at West Springfield, Mass.

The Southern Pacific Company contemplates the construction of a freight and engine terminal including yards, roundhouse and repair shops, at Klamath Falls, Oregon.

The Great Northern Railway contemplates the construction of a new engine house and repair shop at Williston, So. Dakota, estimated to cost $35,000.

The Detroit Toledo & Ironton Railroad is reported to be planning the construction of car shops at Springfield, Ohio, at an estimated cost of $500,000.

The Temiskaming & Northern Ontario Railway has awarded a contract for the construction of an engine house at North Bay, Ont., Canada estimated to cost $75,000.

The Chicago Burlington & Quincy Railroad has awarded a contract for the covering of the foundation car shop at Galesburg, Ill.

The Chicago North Shore & Milwaukee Railroad will construct a one-story brick motor bus garage 80 ft. by 200 ft. at Waukegan, Ill.

The Seaboard Air Line Railway has awarded a contract for repair shop to its engine house and yards at Abbeville, S. C., estimated to cose $15,000.

The Chicago Burlington & Quincy Railroad has awarded a contract to the Graver Corporation, East Chicago, Ind., for the construction of water treating plants at Hannibal, Mo.

The Cleveland & Pittsburgh Railroad is reported to be planning the construction of a new roundhouse and locomotive repair shop at New Philadelphia, Ohio.

The Atlantic Coast Line Railroad has awarded a contract to the Roberts & Schaefer Company, Chicago, Ill., for the construction of a 500-ton capacity two-track, reinforced concrete simplex automatic electric locomotive coaling and sanding plant at Jacksonville, Fla.

The Atchison, Topeka & Santa Fe Railway has awarded a contract to George P. Nichols & Bro., Chicago, Ill., for the construction of a 120-ft. transfer table of 427 tons capacity at San Bernardino, Calif.

The Texas & Pacific Railway is reported to be planning the construction of a roundhouse at Shreveport, La., at estimated cost of $500,000.

The Grand Trunk Western Railway has awarded a contract for the construction of the engine terminal at Battle Creek, Mich.

The Central Railroad of New Jersey is taking bids on the erection of several small shop buildings at Elizabethport, N. J.

The Pere Marquette Railway has appropriated an additional sum of $1,000,000 to be expended in the construction of its yard and related terminal facilities at Erie, Mich.

The Grand Trunk Railway has contracted for a new engine terminal, 40-stall roundhouse, power house and store and office building at Battle Creek, Mich.

The Western Maryland Railroad, it is reported, will build its locomotive shops and engine house at Bowers, Pa., within the next month. These were recently destroyed by fire.

The Southern Railway has reopened bids covering the construction of a ten-story building at Birmingham, Ala.

The Chicago & Alton Railroad is making surveys covering the construction of divisional terminal yards at Louisiana, Mo.

The Denver & Rio Grande Western Railroad is planning a new $1,000,000 terminal at Pueblo, Colo.

The Erie Railroad is reported to be planning the construction of a large freight terminal at Kearney, New Jersey.

The Pacific Fruit Express plans the construction of car repair shops and store sheds at Nampa, Idaho, to cost approximately $450,000.

The Great Northern Railway has awarded a contract for the rebuilding of ten stalls of the enginehouse at Minot, N. D., also for he rebuilding of ten stalls of the enginehouse at Williston, N. D.

The Atchison, Topeka & Santa Fe Railway has awarded a contract for the construction of two additions to its locomotive shops at San Bernardino, Calif.

Items of Personal Interest

D. W. Cunningham, formerly general master mechanic of the Missouri Pacific Railroad has been appointed master mechanic, with headquarters at Jefferson City, Mo.

J. H. Harrison has been appointed general car foreman of the Great Northern Railway, succeeding **A. F. Morton**, resigned. Mr. Harrison was formerly car foreman, with headquarters at Spokane, Wash.

J. A. Sheedy, assistant master mechanic of the Meadow shops of the Pennsylvania Railroad, with headquarters at Jersey City, N. J., has been appointed master mechanic of the Eastern division, with headquarters at Canton, Ohio, succeeding **Mr. DeVilbiss.**

F. E. Copper has been appointed superintendent of the Baltimore & Ohio Railroad shops at Pittsburgh, Pa., vice **C. N. Newman.**

F. G. Grimshaw, superintendent of motive power of the Eastern Ohio division of the Pennsylvania Railroad, with headquarters at Pittsburgh, has been appointed general superintendent of motive power of the southwestern region, with headquarters at St. Louis, Mo., succeeding **E. W. Smith.**

E. B. De Vilbiss, master mechanic of the Eastern division of the Pennsylvania Railroad, with headquarters at Canton, Ohio, has been appointed superintendent of motive power of the Central division, with headquarters at Williamsport, Pa., succeeding **Mr. Bennett.**

J. D. Scott, assistant road foreman of engines, has been appointed acting assistant trainmaster of the Monongahela division of the Pennsylvania Railroad, with headquarters at Youngwood, Pa.

T. F. Ryan has been appointed master mechanic of the Louisville & Nashville Railroad, with headquarters at Birmingham, Ala., succeeding **F. J. Monahan**, deceased.

W. J. Craig has been made district inspector of the Baltimore & Ohio Railroad, with headquarters at Fairmont, W. Va.

R C. Bennett, superintendent of motive power of the Central division of the Pennsylvania Railroad, with headquarters at Williamsport, Pa., has been transferred to the Eastern Ohio Division, with headquarters at Pittsburgh, Pa., with the same title succeeding **Mr. Grimshaw.**

J. B. Merrill has been appointed master mechanic of the Louisville & Nashville Railroad at Montgomery, Ala., succeeding **Mr. Ryan.**

F. A. Sliger has been appointed general foreman of the Baltimore & Ohio Railroad shops at Connellsville, Pa.

Fred Young has been appointed master mechanic of the Dominion Atlantic Railway, with headquarters at Kentville, N. S., succeeding **D. L. Derrom**, resigned.

John Bellmyer has been appointed roundhouse foreman of the Baltimore & Ohio Railroad, with headquarters at East Dayton, O., vice **Frank G. Selirt**, transferred to Toledo, O. **H. M. Gray** has been appointed night foreman at East Dayton, Ohio.

H. S. Wall resumed his duties as mechanical superintendent of the Atchison, Topeka & Santa Fe Railway Coast Lines, with headquarters at Los Angeles, Calif., on June 1st.

P. Kass, general foreman car department of the Chicago Rock Island & Pacific Railway, has been promoted to superintendent of the car department, with headquarters at Chicago, Ill., succeeding **E. G. Chenoweth.**

J. C. Fritts, master car builder of the Delaware, Lackawanna & Western Railroad, with headquarters at Scranton, Pa., has resigned. **C. J. Scudder**, superintendent of motive power and equipment has taken up the duties performed by Mr. Fritts.

F. R. Butts has been appointed assistant master mechanic of the Hannibal division of the Chicago, Burlington & Quincy Railroad, with headquarters at Hannibal, Mo., succeeding **J. J. Simmons.**

J. St. Clair has been appointed engineer of car construction for the Atchison, Topeka & Santa Fe Railway, with headquarters at Chicago, succeeding **E. Posson**, who has resigned.

Supply Trade Notes

The **Safety Car Heating & Lighting Co.** has removed its Chicago offices from the Peoples Gas Building to the Straus Buliding, 310 So. Michigan Avenue.

Ben W. Beyer, Jr., has been appointed district sales engineer of the **Industrial Works**, Bay City, Mich., with headquarters at New York, N. Y. Mr. Beyer was formerly sales engineer for the Union Special Machine Co., Chicago, Ill.

Charles H. Halle has been appointed mechanical engineer of gear cutters for the **Browne & Sharp Mfg. Co.**, Providence, R. I.

The **Chicago Pneumatic Tool Co.**, New York, has opened a branch office at 210 So. Jefferson St., Dallas, Texas, with **J. O. Bailey** in charge.

The **Locomotive Firebox Co.** has moved its general offices to suite 1908 Straus Building, Chicago, Ill.

R. Armstrong has become associated with the **Canadian Brake Shoe & Foundry Co.**, Sherbrooke, Que., as superintendent. Mr. Armstrong was formerly connected with the Canadian Steel Foundries, Ltd.

The **Chicago Pneumatic Tool Co.**, New York, announce the removal of their Los Angeles officers to their new buildings, 655 Santa Fe Avenue, Los Angeles, Calif.

Frederick A. Pope has been appointed supervisor of training of the **Worthington Pump & Machinery Corps.**, with headquarters at New York City.

William H. Woodin, president of the American Car & Foundry Co., has resigned as a director of the **Westinghouse Electric & Mfg. Co.**

The **Hall Switch & Signal Company** has moved its Chicago office to the Straus Building, 310 So. Michigan Avenue.

The **Westinghouse Electric Mfg. Co.** plans the construction of a repair shop and warehouse at Denver, costing $500,000.

The **Bettendorf Co.**, Davenport, Iowa, plans the construction of an electric power plant, with equipment to cost approximately $200,000.

The **Edwards Railway Motor Car Co.**, Sanford, N. C., has let contracts to the **Truscon Steel Co.** for the construction of a building 8 by 150 feet.

The **Union Tank Car Co.**, Philadelphia, Pa., plans the erection of an addition to its construction at repair shop at Point Breeze, Philadelphia, Pa.

John C. Campbell has become associated with the **Ulster Iron Works** at Dover, N. J., with headquarters in the Peoples Gas Building, Chicago, Ill.

William C. Prendergast has been appointed district sales manager of the **Tacony Steel Company**, with headquarters at 2 Rector Street, New York, N. Y.

W. H. Miller has joined the New York office of the **Standard Tank Car Co.** He formerly was traffic manager of the Indian Refining Company at Lawrenceville, Ill.

The **Railway Service & Supply Corp.**, Indianapolis, Ind., has filed its certificate of incorporation with the Secretary of State of New York and will be capitalized at $400,000. **James P. Goodrich**, former governor of Indiana, is president.

W. C. Peters has been appointed manager of sales and engineering of the **National Railways Appliances Co.**, New York City.

Joseph T. Ryerson & Son, Inc., have become exclusive general sales agents of the Lewis brands of iron made by the **Penn Iron & Steel Co.**, consisting of Louis special staybolt iron, Lewis engine bolt iron and drilled hollow staybolts.

L. A. Osborne and **H. P. Davis**, vice-presidents of the **Westinghouse Electric & Mfg. Co.**, have been elected directors, succeeding James C. Bennett and William H. Woodin.

The **Victor Tool Company**, Waynesboro, Pa., manufacturers of Collapsible Taps, Automatic Die Heads, Floating Tool Holders, and Nut Facing Machines has been merged with the **Landis Machine Company**, Waynesboro, Pa., manufacturers of threading die heads and machines. In the future all correspondence applying to Victor products should be addressed to the Landis Machine Company, Victor Plant, Waynesboro, Pa.

The Trade Name "Victor" will continue to apply to the line of Automobile Die Heads, Collapsible Taps, Floating tool Holders and Nut Facing Machines, formerly made by the Victor Tool Company. There will be no change in the sell.ng arrangements of the Victor Product.

This merger permits the Landis Machine Company to handle both internal and external threading requirements.

The Chicago Cleveland Car Roofing Company has located its New York officers at 3710 Grand Central Terminal. **James L. Stark**, general eastern sales representative, will be in charge.

The Metal Safety Railway Tie Co., Jamestown, New York, has purchased the plant of the Birmingham Motors Corp., Falconer, New York, and will use it for making railway ties.

James P. Goodrich, formerly governor of Indiana, is president of the newly organized **Railway Service & Supply Corp.**, Indianapolis, Ind., capitalized at $400,000.

L. D. Albin, formerly general sales manager of the **Ingersoll-Rand Company**, New York City, has been elected vice-president in charge of European sales of the company. **D. C. Keefe**, formerly assistant general sales manager, has been appointed to succeed Mr. Albin as general sales manager.

Howard A. Gray has resigned from the **Joseph T. Ryerson & Son, Inc.**, and has secured the agency for the products of the **Ulster Iron Works**, formerly handled by Joseph T. Ryerson & Son, Inc.; his headquarters will be at Chicago.

F. M. English has been appointed assistant sales manager of **Reading Iron Company**, to succeed A. F. McClintock, whose resignation was announced June 1.

John W. Fogg, formerly general sales manager of **Boss Nut Co.**, has been appointed as assistant to the vice-president of the **American Bolt Corporation**, Boss Nut division.

New Publications

Books, Bulletins, Catalogues, Etc.

Laminated Springs. By T. H. Sanders, M. I. Mech. E., M. I. & S. I. London: The Locomotive Publishing Co., Ltd. New York: Spon & Chamberlain. 509 pages, 282 illustrations. Price 25/ net.

In view of the importance attaching to the design and manufacture of laminated springs, it is curious that the literature dealing with this subject is so meagre as to be practically negligible. From time to time, odd papers read before technical institutions, or articles in the technical press, appear in connection with plate springs, but so far as is known, no text book has been published in any country dealing specially with this essential rolling stock detail.

In his treatise on "Laminated Springs," Mr. Sanders has done much to fill the gap existing in technical literature on this subject, and the author's pages bear evidence of his exceptional qualifications to undertake a work of this nature; since his intimate knowledge of theoretical detail is obviously sustained and expanded by experience of the special manufacturing conditions and commercial applications which have such an important bearing on the purely academical aspect. Mr. Sanders is to be commended for his treatment of a highly mathematical subject with the use only of elementary mathematics, and those readers whose recollection of calculus is but a painful memory, need have no apprehension as to their ability to follow the author through his theoretical disquisitions.

This volume is divided into two portions: Part "A" deals with "Calculations and Designs," and Part "B" with "Manufacture." In the first, the author discusses first principles involving the deflection of beams at considerable length, and has derived therefrom the key formulæ relating to the corresponding deflections of laminated springs. These have been carefully traced, and various correcting factors are studied in detail in order to provide for the accurate calculation of any design of plate spring.

In the second portion of the work, the author treats at length the manufacture, composition, rolling and sections of spring steels, and makes a special plea for the standardization of sections in British practice. Methods of manufacturing all types of back plates are systematically elaborated with many illustrations, and chapters of special interest in this portion of the book deal with the actual spring making and heat treatment. The latest American systems for the production of automobile springs are described, with numerous patterns of plate forming machines. The concluding chapters of the book are devoted to material and manufactur.ng processes for iron and steel spring hoops, or buckles.

We cannot pretend to give more than a brief summary of a remarkable and most informative work, but we would emphasize its value in indicating the wideness of its scope, as it deals impartially with British, Continental and American practices, both as regards spring design, manufacture and machinery; and covers the whole fields of laminated springs as required for railway and tramway rolling stock, and automobiles. The chapters dealing with various forms of back or top plates include on the three leading illustrations no less than 107 drawings showing different types.

Superheated Steam Pyrometers: The Superheater Company, of New York and Chicago, have just issued a second edition of its Instruction Book covering installation, operation and maintenance for Model 496 Superheated Steam Pyrometers. While the book is intended primarily to give instructions covering the application of the Pyrometer to Superheater Locomotives, there are also given special instructions relating to Marine and Stationary Industrial plants. A Pyrometer Test Set is described and inspection of the Pyrometer and tests of various parts with and without the Test Set are given. An added feature of this description of the book is the order list covering Pyrometer parts in the back of the book. A copy of this book will be gladly sent to anyone mentioning this publication.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

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Mountain Type Locomotive of the Pennsylvania Railroad

A New Design for Heavy Passenger Service

Sometime ago the Pennsylvania Railroad completed at its Altoona Works a passenger locomotive of new type, which is forty-five per cent more powerful than the Class K-4s, Pacific type, its present standard design of locomotive for hauling heavy passenger trains.

The new locomotive, known as Class M-1, is of the mountain type, 4-6-0 wheel arrangement, which has not heretofore been used on the Pennsylvania.

The general appearance of the engine ready for service is shown in the half-tone reproduction of the photograph.

The M-1 was designed in anticipation of the future demands of the passenger service for more powerful locomotives, and the one locomotive just built will be thoroughly tested in service to insure that it will efficiently and economically meet the requirements.

It is expected that in coal and steam economy the M-1 will duplicate in the passenger service the very satisfactory performance of the new Class I-1s locomotives in the freight service.

Higher boiler pressure, longer piston stroke, and smaller diameter of driving wheels are the principal features in securing the forty-five per cent increase in power with an increase of but twenty-five per cent in the weight of the locomotive, compared with the Class K-4s.

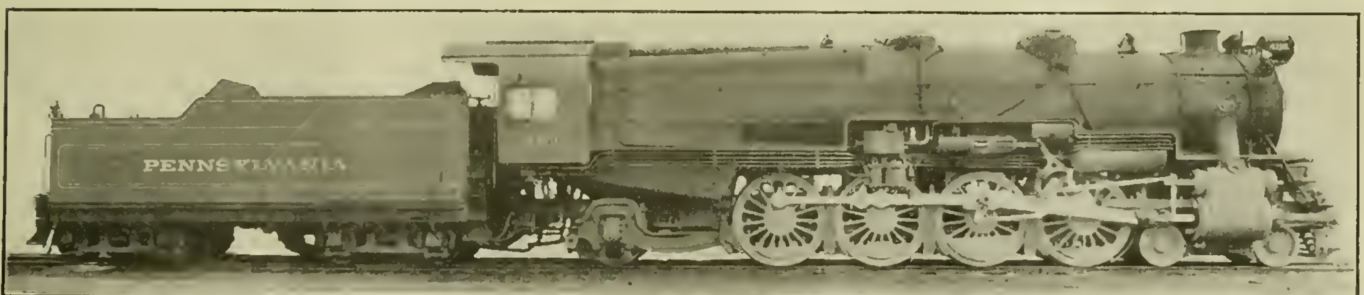
To facilitate shop work and maintenance the front and trailer trucks and certain other details have been made interchangeable with those of other classes of passenger locomotives of the road.

The Class M-1 has cylinders 27 inches diameter, with 30 inch stroke, driving wheels 72 inches in diameter, and with a boiler pressure of 250 pounds per square inch develops a tractive or starting power of 64,550 pounds. In working order the locomotive and tender weigh approximately 544,000 pounds. Their total length is 84 feet 9⅝ inches.

This is the second new design of passenger locomotive developed and built by the Pennsylvania during the past year, the other being the ten-wheeler, Class G-5s, which was turned out in July, 1923, and a detailed description of which was published in the November, 1923, issue of Railway and Locomotive Engineering. The Class G-5s engines are used in local and suburban service. Forty of them have since been built at the Altoona Works, and these are giving very satisfactory service at different points on the system.

The general dimensions of the new Mountain type locomotive are as follows:

Cylinders, 27″ by 30″.



New Mountain or 4-82 Type Locomotive of the Pennsylvania Railroad

Steam pressure, 250 pounds.

Boiler—Type, Belpaire diameter 82″.

Tubes—2¼″ diameter, 114; 1 3/16″ diameter, 400; 3¼″ diameter, 200.

Heating Surface—Tubes, 4,508 square feet; superheater, 2,469 square feet; firebox, 410 square feet; total, 7,387 square feet.

Grate, 79⅞″ by 126″; 70 square feet.

Driving wheel diameter, 72″.

Trailing wheel diameter, 50″.

Truck wheen diameter, 33″.

Wheel base engine, 41′ ½″.

Total wheel base, 76′ 7″.

Weight of engine, 383,100 pounds.

Weight of engine and tender, 559,600 pounds.

Conservation of Locomotive Fuel

"The Stone Which the Builders Rejected Was Made the Head of the Corner"

By W. E. SYMONS

Since the first article on this subject in Railway and Locomotive Engineering several months ago, many things have transpired in the fields of commerce, transportation, diplomacy and engineering, and in most of these human activities may be found appropriate reference to the above captions.

It is not the author's purpose to switch from engineering to theology as some might infer from the combined headings, but rather to use both in their proper place and sense.

As stated in previous articles, great strides have been made during the past twenty years in developing the American locomotive to its present state of efficiency, and notwithstanding all the improvements made in the locomotive alone, the devices or accessories that are an integral part of most all modern engines contribute much to the efficiency of the complete unit, in fact some of the greatest fuel saving devices are of somewhat modern application and in some cases the merits of the device were not recognized until long after it should have been in more general use. In other words we were in many instances, looking for *quarters* and stumbling over *five dollar bills.*

It is indeed gratifying to note there is in certain quarters no little activity in this fuel economy question, although some are just waking up, and a few we regret, are evidently still in the *"Sweet Arms of Morpheus."*

Interesting Inquiries and Comments

Some of the incidents in connection with this problem are both interesting and amusing to the author and it is thought a few examples might be to our readers.

1. One very much interested railway executive says: "I have read your articles on fuel economy and note you state, many have strained their eyes looking for nickels while stumbling over *five dollar bills.* To this I was at first disposed to take umbrage, but on checking up with an expert, I now think we have been stumbling over *ten* ($10) *dollar bills,* and quite a few of them."

2. A mechanical officer on a large system says: "As a result of your articles on fuel conservation, and particularly the question of excessive back pressure on pistons, we are going through all our front ends from *stem* to *gudgeon,* cleaning out and enlarging exhaust nozzles, etc., and as a result of this and other economies in fuel we expect to make a saving of $150,000 to $200,000 in one year."

3. A purchasing agent on a big system asks for information as follows:

"For many years this department has bought on properly approved requisitions from the mechanical department, at greatly increased cost to this company, improved devices, accessories or integral parts of locomotives, which the inventors, manufacturers or promoters claimed would effect great economies in fuel consumption, the amounts ranging from 5 per cent to as high as 30 or 40 per cent, and as many of our engines of more recent years are now equipped with these devices, why is it that our fuel bill is increasing instead of decreasing as I expected it would. Just from memory I give you the respective percentages of saving which I had thought would be realized from the use of this additional apparatus.

Superheaters 25 per cent. Feed water heaters 20 per cent. Brick arches 15 per cent. Thermic Syphons 15 per cent. Roller side bearings 10 per cent. Improved lubrication 15 per cent. Flange oilers 5 per cent. Fire doors, sanders, etc., 5 per cent. Total, 110 per cent. And now that we have all these things the fuel bill is *going up, not coming down,* as I expected; and now you tell us that by relieving excessive back pressure on pistons a great improvement can be made, what's wrong? I seem to be all twisted up in a lot of percentages. Can you straighten me out?"

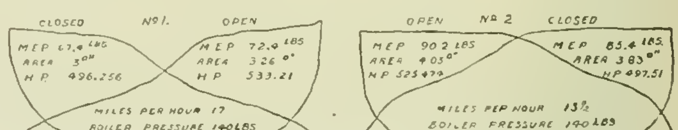
Of course a full answer to this proposition requires a lot of explaining as to percentages of a per cent, or fractional part thereof, frequently being a small part of the whole, and that most fuel savings are predicted on service tests under maximum sustained load only, etc., etc., and *not* on the complete fuel bill.

4. A consulting engineer and railway expert has this to say:

"I am much interested in your articles on fuel economy, particularly the feature of excessive back pressure on pistons, which I have no doubt will result in action at once on many railways, that will increase the efficiency of locomotives and effect a great saving in fuel. It seems too bad that no one discovered this feature or at least did not mention it until now, when if it had been discovered and properly exploited a few years ago, the railways might have already saved anywhere from fifty to one-hundred million of dollars and had more efficient power, thus effecting a double economy in operation."

In answer to the last gentleman's comments will say, we are not to blame for the things we do not know, if they are not matters coming properly within the purview of one's duties, study or profession, but if the reverse is true, then one is not free from censure.

About thirty years ago the writer took up this matter of excessive back pressure on pistons of engines on one of the heavy divisions in the Rocky Mountain district, and not only effected quite a reduction in fuel used but



Indicator Diagrams from Locomotive Equipped with Adjustable Nozzle Device

rendered engines more efficient, by keeping exhaust nozzles up to maximum opening and free of deposits, and in order to avoid frequent opening of front ends at terminals to adjust nozzles to suit changes in fuel, etc., a device was applied whereby the exhaust steam and back pressure on pistons could be regulated by the engineer when under way.

This device increased the efficiency of the engine very materially and saved about two tons of coal in 105 miles run, and in that service the money saving on fuel would have been about $800 per year on one engine with coal at $3.00 per ton.

Indicator cards taken from the engine equipped with this device in 1893 and 1894 are shown herewith.

Some five years later a more efficient, inexpensive, and thoroughly reliable device was developed and successfully used. The results of the tests and the indicator cards showing reduction in back pressure on pistons were published at that time and are available now should anyone desire to consult them.

Just why there has been so little done in this matter during the past 25 or 30 years I am unable to say, except that the eyes of our railway designing engineers and experts in economies have focused on other parts of the machine or features of operating expense, although they cannot deny that the proposition has been *staring them in the face* and *crying for relief* for the past 30 years or more.

Fuel Bill for 25 Years

The gentleman is right in suggesting that a saving of anywhere from $50,000,000 to $100,000,000 might have been made by the railways in fuel, plus the value of increased efficiency of locomotives if this feature had been properly exploited or corrected some years ago, although if made when other features of design were undergoing important changes 25 years ago the amount of saving could conservatively be estimated at well above the $100,000,000 mark.

A tabulation of costs of locomotive fuel, the proportion it bears to operating expenses and the flat price of coal at the mines for the years 1899 to 1923, inclusive, is here presented, and attention is invited to gradual increase in price, and that the total bill for 25 years is above $7,000,000,000, or more than one-third the value of our entire railway properties, which is conservatively placed at about $21,000,000,000 to $22,000,000,000.

Year	Cost of Locomotive fuel	Proportion Operating Expenses	Cost per ton at mines
1923	$617,800,000	10.81	$3.12
1922	523,724,145	11.74	3.02
1921	535,305,769	11.49	2.89
1920	689,632,039	11.58	3.22
1919	485,574,445	10.89	2.47
1918	512,786,938	12.64	2.56
1917	401,297,303	13.92	2.07
1916	257,371,124	10.49	1.24
1915	216,895,203	10.38	1.13
1914	242,800,799	11.03	1.17
1913	249,507,624	11.49	1.18
1912	234,246,470	11.87	1.15
1911	231,693,773	12.09	1.11
1910	217,780,953	11.95	1.12
1909	188,735,860	11.80	1.07
1908	201,905,054	12.09	1.12
1907	200,261,975	11.47	1.14
1906	170,499,133	11.11	1.11
1905	156,429,245	11.27	1.06
1904	158,948,886	12.12	1.10
1903	146,509,031	11.67	1.24
1902	120,074,192	10.77	1.12
1901	104,926,556	10.60	1.05
1900	90,593,965	9.80	1.04
1899	77,187,344	9.47	.87
Total	$7,032,487,834		

From the foregoing it would seem proper to state that the amount which might have been saved would depend on; (a) how far back the economies became effective, (b) the amount of excessive back pressure removed and (c) number of engines and price of coal per ton.

With these factors it would not be difficult to estimate what the past saving might have been, and what the future holds in store on this important item of operating expense.

Should this feature of locomotive improvement now receive the attention it deserves, then the scriptural quotation embraced in the title of this article will have, in a measure, not only been fulfilled, but the credit side of the ledger will show the saving in *millions*.

Traveling Engineers' Association Convention

The thirty-second annual convention of the Traveling Engineers' Association will be held at the Hotel Sherman, Chicago, Ill., commencing Tuesday morning, September 16, and continuing until the 19th, inclusive.

The convention promises to be one of the most interesting and educational ever held in the history of the association.

The papers to be read or presented for discussion at the convention will include the following:

"How can the work of the Traveling Engineer be made more effective, and can the usual number of Traveling Engineers properly take care of the duties expected of them?"

"Conservation of Locomotive Fuel, both oil and coal, and the feed water heater."

"Lubrication and its effect on locomotive service."

"What effect will the mechanicaly fired locomotive have on the future engineer?"

"Locomotive Booster and their effect on locomotive design and train operation."

"How can oil burning be improved on locomotives?"

"Relation between terminal facilities and locomotive service."

"Recommended Air Brake Practice."

"Automatic Train Control and Devices."

Concrete Railway Cars

Iron and wood floors in railway cars may be replaced by cement, if experiments recently conducted in Germany continue to prove successful. A composition designated as "Eisenbeton" (iron wood) has been used in the construction of the floors of railway freight cars with a great measure of success. The first car made of this substance was built in 1919 by a railway-car manufacturer and a Portland cement concern in Heidelberg, and was tested in the railroad freight yards. The car withstood concussion at a speed of 27 kilometers, and shifting tests were so satisfactory that after five years of service this test car still remains in perfect condition.

The new type of car weighs 20 tons, and in appearance is much the same as an ordinary iron car. The cost of manufacture is much less than for iron, and although the concrete car is much heavier, the fact that the danger of rust is eliminated offsets this disadvantage. The car with concrete floor requires so little repair work in comparison with wood and iron cars that the railway administration is favorably impressed, since the yearly expenditure for repairs on the old type of cars reaches a considerable amount.

A company for the manufacture of these cars has been formed at Darmstadt.

Cars and Locomotives Placed in Service

Class 1 railroads during the first six months this year installed in service 70,874 freight cars, according to reports filed by the carriers with the Car Service Division of the American Railway Association. This was a decrease of 8,366 cars as compared with the number installed during the corresponding period in 1923. The railroads on July 1, 1924, had on order 60,315 freight cars as compared with 96,855 on July 1, 1923, or a decrease of 36,540.

The railroads during the first half of 1924 also installed 1,071 locomotives, as compared with 1,998 during the corresponding period the year before, or a decrease of 927. They also had on order on July 1, 360 locomotives, as compared with 1,902 last year.

Recent Developments in Electric Locomotives

By N. W. Storer, General Engineer, Westinghouse Electric & Mfg. Co.

A Paper Presented at the Railroad Session of the Spring Meeting of the American Society of Mechanical Engineers

While there have been comparatively few instances of steam railroad electrification since the close of the World War, there have, nevertheless, been several very important and significant electrifications that have stimulated the development of the electric locomotive and indicated world-wide interest in electrification. In spite of the poverty of the war-stricken countries in Europe, railway electrification is progressing or under active discussion in nearly all of them, stimulated in most places by the high cost of coal and the possibility of using water power. Two large installations are being made in South Africa; two or more in South America; Australia is in the market for additional electric-railway equipment; and others are progressing in the East Indies and Japan.

The principal new locomotives in which the company the author represents has had a part are listed, with their principal dimensions, weights, type, etc., in Table 1.

Paulista Railway Locomotives

Two types of Baldwin-Westinghouse locomotives were built for the Paulista Railway of Brazil, as shown in Table 1. The freight locomotive has six driving axles

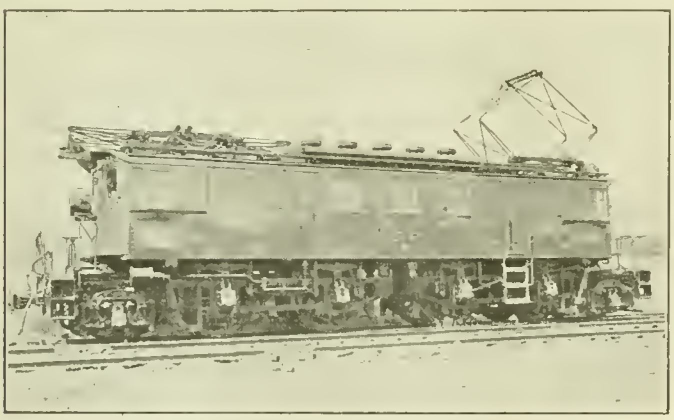


Fig. 1—Central of Paulista Passenger Locomotive

contained in two articulated trucks. Each axle has a motor geared directly to it. The motors are wound for 1,500 volts each and are operated with two or more in series at all times. There are three combinations of motors: first, six in series, giving one-third speed; second, three in series, two in parallel, for two-thirds speed; third, two in series, three in parallel for full speed. There is in addition a higher speed in each combination, obtained by tapping the fields of the motors. Regenerative braking is obtained at all speeds with full power.

In speed combinations the control system follows the precedent of the Baldwin-Westinghouse locomotives which have operated so successfully on the Chicago, Milwaukee & St. Paul Railway, but the control in general is simpler than that of the Milwaukee locomotives because there is neither train lighting nor heating to be supplied from the locomotive. The power for exciting the main motors during regeneration for auxiliary motors and for the locomotive lighting and control circuits is all furnished at a low voltage from a small motor-generator set, so that there is no high voltage on anything outside of the main motors and control apparatus except the motor of this motor-generator set. This makes a relatively simple as well as rugged and reliable equipment.

The cabs of these locomotives rest on spring-supported H-frames, which form a flexible link between the cab and truck frames. The H-frame carries the center pin. This construction gives a very easy riding cab.

The passenger locomotives, as in Fig. 1, are of the 2-4+4-2 type, each driving axle having a twin motor geared to a quill surrounding the axle, which is connected to the wheels by the well-known long helical spring in use on the New York, New Haven and Hartford Railway. The armatures and other electrical features of these twin motors are interchangeable with the motors of the freight locomotive so that this locomotive has one-third

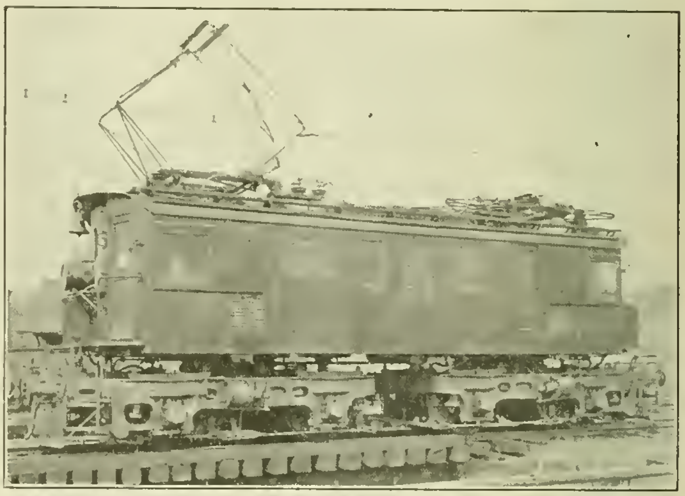


Fig. 2—Chilean State Local Passenger Locomotive

more power than the freight locomotive with only four driving axles instead of six. This gives a much better utilization of the weight than would be possible with eight driving axles. The cab of this locomotive rests on spring supports but the center pin is carried directly in the cross-tie of the truck.

These locomotives are also designed for regenerative braking with full power on the motors.

Both of these locomotives have been remarkably successful in operation.

Chilian State Railways

The Chilean State Railways are equipped with overhead trolley with 3000 volts direct current. The four types of locomotive built for this railway all have motors geared dierctly to the driving axles. Like practically all foreign locomotives, these are designed for light axle loading, the rules of the railway placing the maximum weight per axle at approximately 40,000 lb. The switcher is of the usual standard, light, double-truck type, with four driving axles. The local passenger locomotive of Fig. 2 is similar to this but has articulated trucks. One notable feature of this locomotive is that the truck frames are cast in one piece, as shown in the photograph.

The freight locomotive of Fig. 3 is very similar to the freight locomotive for the Paulista Railway which has just been described, the chief difference being that the weight has been reduced somewhat, due to changes in the mechanical parts.

TABLE 1 DATA FOR NEW ELECTRIC LOCOMOTIVES

Railroad		Number in service	Class of service	Contact voltage	Conductor type	Type of loco.	Class, by wheels	Driving wheels No.	Driving wheels diam.	Truck wheels No.	Truck wheels diam.
Paulista Railway	1	2	Pass.	3,000	Catenary	d.c.	2-4 + 4-2	8	63"	4	36"
	2	2	Frt.	3,000	Catenary	d.c.	0-6 + 6-0	12	40"	..	...
Chilean State Railway	1	6	Ex. Pass.	3,000	Catenary	d.c.	2-6 + 6-2	12	42"	4	30"
	2	11	Local Pass.	3,000	Catenary	d.c.	0-4 + 4-0	8	42"	0	...
	3	15	Frt.	3,000	Catenary	d.c.	0-6 + 6-0	12	42"	0	...
	4	7	Switcher	3,000	Catenary	d.c.	0-4 + 4-0	8	42"	0	...
N. Y. N. H. & H. R. R.		12	Pass.	600 11,000	d.c. 3rd rail a.c. Catenary	d.c. & 1 ϕ a.c.	2-6-2 + 2-6-2	12	63"	8	36"
Norfolk & Western		8 M.P.U.	Frt.	11,000	Catenary	a.c.	2-8-2	8	62"	4	33"
The Virginian		36 M.P.U.	Frt.	22,000 11,000	Catenary	a.c.	2-8-2	8	62"	4	33"
Pennsylvania	1	2	Pass.	650	3rd rail	d.c.	2-8-2	8	80"	4	33"
	2	1	Frt.	11,000	Catenary	a.c.	2-8-2	8	80"	4	33"

Railroad		Articulated trucks	Wheelbase: Rigid	Wheelbase: Total	Weight in Pounds: Total road wt.	On drivers	Per driving axle	Mech. parts	Equipment[1]
Paulista Railway	1	Yes	8' 4"	41' 2"	283,800	205,800	51,450	165,400	118,400
	2	Yes	14' 0"	37' 0"	234,300	234,300	39,050	144,050	90,250
Chilean State Railways	1	Yes	14' 5"	48' 4"	259,800	210,000	35,000	153,966	105,834
	2	Yes	8' 4"	26' 0"	160,000	160,000	40,000	93,000	67,000
	3	Yes	13' 9"	37' 0"	230,000	230,000	38,333	138,400	91,600
	4	No	8' 6"	27' 4"	137,000	137,000	34,250	80,900	56,100
N. Y. N. H. & H. R. R.		Yes	14' 3"	59' 6"	358,000	240,000	40,000	175,200	182,800
Norfolk & Western		No	16' 6"	37' 6"	414,000	300,000	75,000	251,500	162,500
The Virginian		No	16' 6"	37' 6"	414,000 approx.	300,000	75,000	......	......
Pennsylvania	1	No	22' 3"	54'11"	400,000	300,000	75,000	225,100	174,900
	2	No	22' 3"	54'11"	408,000	300,000	75,000	225,100	182,900

[1]Includes sand, air brakes, etc.

Railroad		Dimensions: Length overall	Width overall	Height trolley down	Regen. Control	Motors: No.	Method of drive	Gear ratio
Paulista Railway	1	52' 11"	10' 7"	14' 10"	Yes	4 Twin	Geared quill	28 : 86
	2	50' 2"	10' 6.5"	14' 10"	Yes	6	Geared	16 : 63
Chilean State Railways	1	58' 5"	10' 6.75"	14' 4 7/16"	Yes	6	Flex. gear	21 : 56
	2	38' 9.5"	10' 7"	14' 2 3/16"	No	4	Flex. gear	21 . 56
	3	49' 9.5"	10' 6.75"	14' 4 7/16"	Yes	6	Flex. gear	15 : 63
	4	40' 0"	10' 6.75"	14' 2 3/16"	No	4	Gear	16 : 63
N. Y. N. H. & H. R. R.		68' 6"	10' 2.5"	Over d.c. trolley down 14' 9½"	No	6 Twin	Geared quill	25 : 89
Norfolk & Western		48' 7"	10' 5"	16' 0"	Yes	2	Flex. geared jack shaft and side rod	21 : 100
The Virginian		......	10' 5"	16' 0"	Yes	2	Flex. geared jack shaft and side rods	......
Pennsylvania	1	68' 2.5"	10' 3"	15' 6"	No	4	Flex. gear and side rod	50 : 98
	2	68' 2.5"	10' 3"	15' 6"	No	4	Flex. gear and side rod	30 : 118

Railroad		Tractive Effort in Pounds: One-hour rating F. V.	Per cent coeff. of adhesion	Continuous rating F. V.	Per cent coeff. of adhesion	Starting
Paulista Railway	1	20,960	10.0	14,240	6.9	54,400 maximum
	2	32,400	13.8	21,600	9.2	77,310 33% adh.
Chilean State Railway	1	25,800	12.3	19,800	9.4	70,800 maximum
	2	17,200	10.8	13,200	8.3	47,200 maximum
	3	31,200	13.6	24,360	10.6	75,900 33% adh.
	4[2]	23,000	16.8	11,000	8.0	45,210 33% adh.
N. Y. N. H. & H. R. R.		23,160	9.66	16,200	6.66	52,500 maximum
Norfolk & Western (2 M.P.U.)	8 P	108,000	18.0	90,000	15.0	185,000 maximum
	4 P	63,000	10.5	52,500	8.75	110,000 maximum
The Virginian		......	....	......	...	....
Pennsylvania	1	44,000	15.47	36,000	12.64	86,000 maximum
	2	59,000	19.72	50,000	16.66	100,000 33% adh.

[2]Self-ventilated. F. V. = force ventilated.

Railroad		Speed, Miles per Hour: One-hour rating	Continuous rating	Maximum safe	Horsepower of Locomotive: One-hour rating F. V.[3]	Continuous rating F. V.[3]	Builder of mechanical parts
Paulista Railway	1	42.8	47.2	65	2,400	1,800	Baldwin
	2	20.8	23.4	42	1,800	1,350	
Chilean State Railway	1	36.0	39.75	63	2,460	2,040	Baldwin
	2	36.0	39.75	56	1,640	1,360	
	3	21.5	23.0	44	1,800	1,500	
	4	10.5	12.75	35	640	384	
N. Y. N. H. & H. R. R.		32.6	38.4	77	2,016	1,656	Baldwin
Norfolk & Western (2 M.P.U.)	8 P	14.10	14.20	38	4,060	3,400	American
	4 P	28.30	28.40	..	4,750	4,000	
The Virginian		....	....	..	4,060	3,400	American
		....	....	..	4,750	4,000	
Pennsylvania	1	35.9	37.8	70	4,100	3,630	Penna. R. R.
	2	21.00	23.0	35	3,300	3,070	

[3]F. V. = force ventilated.

The passenger engine of Figs. 4 and 5 has a similar equipment, but has a pony truck at each end of the locomotive, which was deemed desirable on account of the higher speeds of operation.

The control equipments for these two locomotives are practically identical, each locomotive being arranged for three speeds with corresponding motor combinations and three additional speeds from tapped fields. Full power regeneration at all speeds is also provided for.

New York, New Haven and Hartford Locomotives

The locomotives for the New Haven road listed in the table belong to what is known as the 0300 class and are duplicates of those built in 1919 for the same railway. They are built for heavy, high-speed, passenger service. While these locomotives are not of a new type, they are listed here because they are the standard of the New York, New Haven and Hartford and an order for twelve has just been completed. Another reason is to call attention to the different type. These locomotives, as shown in the photograph of Fig. 6, are of the 2–6–2+2–6–2 type. Each driving axle is driven by a twin motor through gears, quill, and springs. Each axle is independent, just as if it were driven by an axle-hung motor. The control equipment is complicated by the fact that the locomotive must run either from the 11,000-volt, single-phase, overhead trolley or from the 600-volt d.c. third rail in the terminal district of the New York Central Railway. However, the control is thoroughly reliable and the satisfactory performance of the locomotives is attested by the fact that after several years' operation with five of these locomotives, twelve more were purchased.

An interesting feature of this locomotive is the one-piece casting which constitutes the entire frame of the truck. This can be seen in the photograph. It is strong and relatively light.

Like the locomotives of the Chilean State Railways, these had to be designed for a light axle loading on account of the bridges over which they had to pass, and the one-piece truck frame assisted very materially in keeping the weight down to the desired limit.

Norfolk and Western Locomotives

These locomotives, shown in Fig. 7, are designed for operation from an overhead trolley with 11,000-volt, single-phase, alternating current of 25 cycles. They are of the split-phase type, i.e., the single-phase current taken from the trolley passes through a transformer and phase converter on the locomotive and is transformed into three-phase current, which is used by the three-phase induction

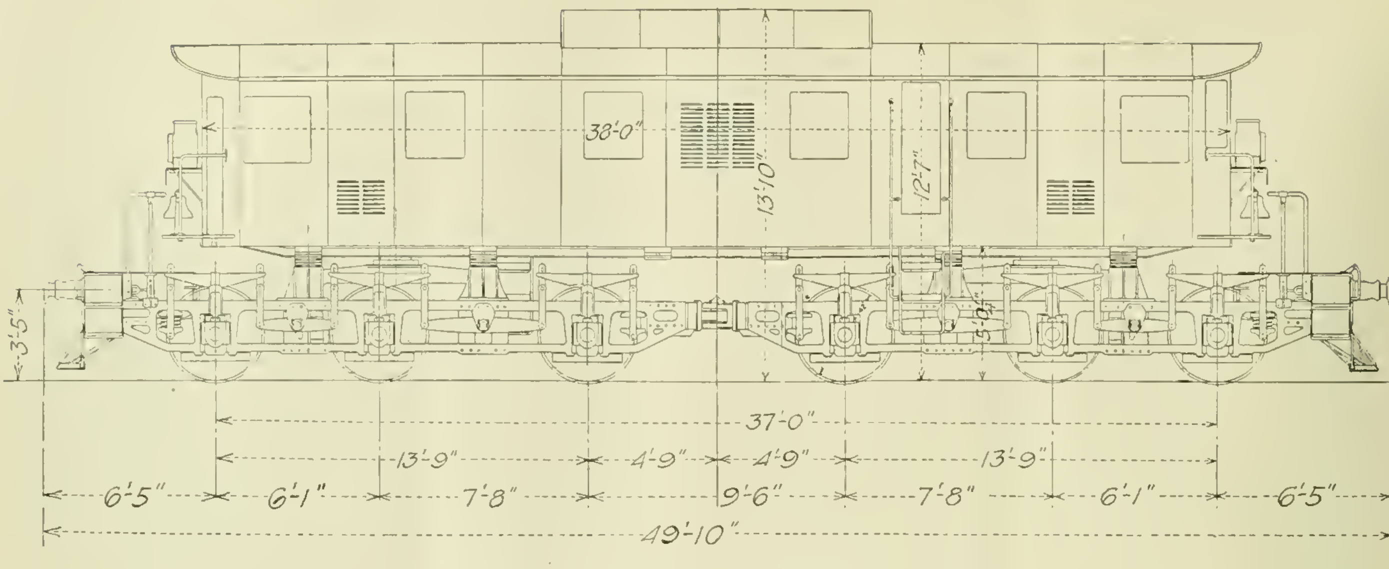


Fig. 3—Chilean State Railways Electric Freight Locomotive

driving motors. These locomotives will be operated at 14 and 28 m.p.h., like the locomotives which are now in service. While following the same general system of control, they have, however, many improvements over the old ones, some of which are noted hereafter.

The most prominent difference lies in the mechanical design. These locomotives have a 2-8-2 wheel arrangement, with rigid frames, while the original locomotives were 2-4+4-2, with the cab resting on the trucks. A second important difference lies in the fact that only two motors are used on each cab instead of four, as in the original locomotive, although the capacity of the locomotive is approximately 30 per cent greater.

The main motors are mounted directly above the jackshaft and are arranged so as to be overhauled by lifting them out through a hatchway in the roof. The motors are arranged with collector rings on both ends of the rotor, located outside of the pinions and readily accessible. The pole-changing switches, reversers, and blowers are mounted on the motor frame, which gives an extremely compact job of wiring.

The liquid rheostats which are used for accelerating and for varying the speed of the locomotive are of an improved type, so designed that the engineer has individual control of all the rheostats. The electrolyte is in constant circulation and is kept cool by a current of air passing through it as it falls over shelves in the rheostat.

Oil-insulated transformers are used which are cooled by circulating oil through a radiator which is provided with a forced draft.

Each motor is connected to two pairs of drivers by means of gears, jackshaft, and side rods. These are of an extremely massive design suited for the heavy service for which they are intended. The gears are flexible, with a leaf type of spring.

The cabs are built for single-end operation since they are always operated in pairs.

The Virginian Railway Locomotives

The locomotives that are listed for the Virginian Railway are now under construction. They are designed, like the Norfolk and Western, for an overhead trolley with 11,000-volt single-phase current. The locomotives themselves are of the split-phase type with equipments duplicate of those on the Norfolk and Western locomotives, which have just been described. The mechanical parts have been modified somewhat, chiefly in order to fit them for operating with three or four cabs or motive-power units, coupled together, since it is desired to handle very heavy trains on the grades, which will require a locomotive with three motive-power units at the head of the train and three at the rear.

The Pennsylvania Locomotives

The Pennsylvania Railroad has under construction three locomotives. They are designed for operation from an

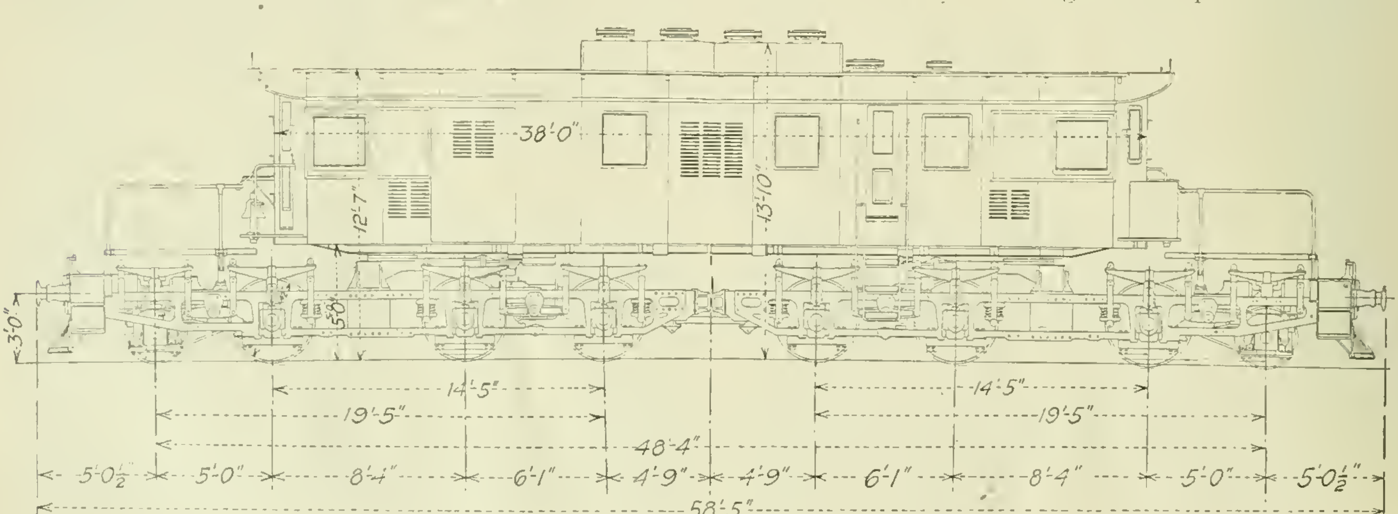


Fig. 4—Chilean State Railways Express Passenger Locomotive

overhead trolley, with 11,000-volt, 25-cycle alternating current.

Like the Norfolk and Western locomotive, these are of the 2-8-2 design, with gear and side rod drive. However, they are variable-speed locomotives, designed primarily for heavy- and preference-freight service on the main line of the Pennsylvania, but are to be tried out in passenger service as well. Each jackshaft is driven by two single-phase commutator-type motors, each with a continuous rating of 760 hp., which are geared so as to develop the full rating of the locomotive of 50,000 lb. tractive effort at 23 m.p.h. These motors are furnished by the Westinghouse Company and consist simply of the armatures and the stator rings with the field laminations built into light castings which carry the windings and the rocker rings in which the brush holders are mounted. The bearings and the cradle which carry the stator are designed as a part of the mechanical part of the locomotive.

The gears are flexible, similar to those of the Norfolk and Western. The pinions of the motor next to the drive

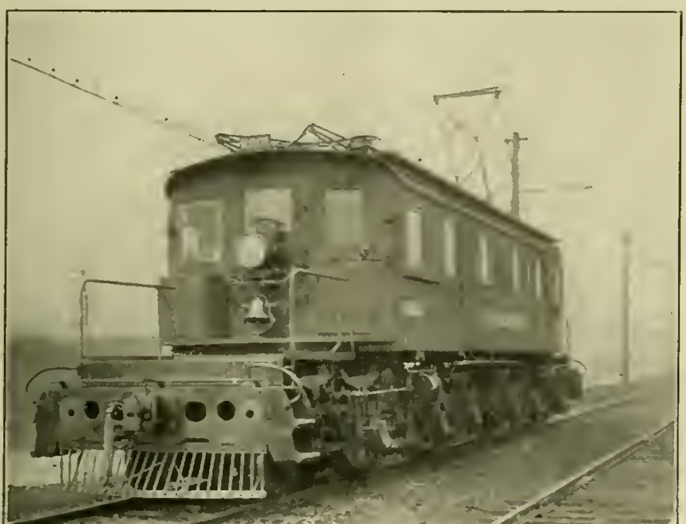


Fig. 5—Chilean State Passenger Locomotive

wheels are solid while those on the outside motors are flexible.

The cab is of the steeple type, arranged so the hoods can be removed to give access to the motor or for its removal. The cab itself is small and requires space simply for the motorman's compartments and transformer, air compressor, and a small amount of control apparatus. The reversers and blowers for the main driving motors are carried under the hood. Contrary to the usual custom, the air is exhausted from the rear end of the motor rather than being blown through it. This has the advantage of removing the hot air from the cab as well as making the commutator more accessible.

These motors are the largest single-phase motors that have been built in this country. They have eighteen poles and are designed for a speed range of from 23 to 35 m.p.h.

The weight efficiency of this locomotive is exceptionally high. The total is only about 200 tons, which is about evenly divided between the mechanical parts and the equipment.

Two of these locomotives are to be used with direct-current control equipment in the Pennsylvania Terminal in New York, where they will be operated in passenger service.

The Motor Generator Type of Locomotive

Another type of locomotive which has been discussed more or less in the last few months is the motor-generator type, which it was announced some time ago was being built by the Ford Motor Company for the electrification of the D. & I. Railway. This locomotive will operate under a 22,000-volt, single-phase, 25-cycle trolley, but will utilize the current in a different way from any of the foregoing locomotives. The locomotive will have an oil transformer which will reduce the voltage to a low value for a synchronous motor which drives a direct-current generator. This generator will furnish current for direct-current motors mounted on the axle of the locomotive.

This is a most interesting announcement, as it revives the motor-generator idea which was proposed a good many years ago but was neved used except in one or two very small locomotives. The reason for adopting this now is that recent developments in machine design have made

Fig. 6—New York, New Haven and Hartford Locomotive

it possible to design a motor-generator set of sufficient capacity for heavy locomotives without excessive weight or dimensions. The control of a motor-generator type of locomotive is ideal, as all of the motors may be connected permanently in parallel and supplied with current from the generator at any desired voltage. The control of the motor fields will permit the locomotive to develop its full horsepower rating over a wide range in speed and

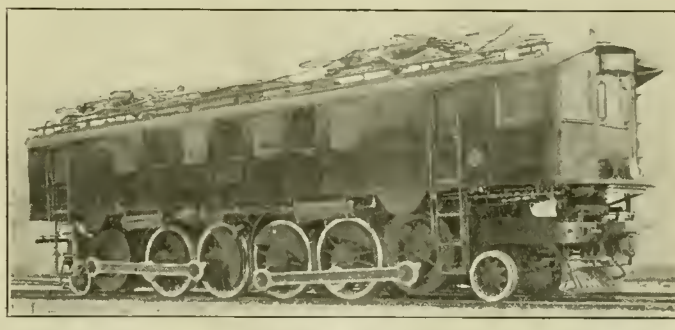


Fig. 7—One Motive-Power Unit, Norfolk and Western Locomotive

thus to secure one of the excellent characteristics of the steam locomotive.

It may appear at first thought that a motor-generator type of locomotive is simply a direct-current locomotive with transformer and motor-generator set added. Such is not the case. The motors, themselves will be smaller and more rugged than high-voltage direct-current motors, since they may be wound for low voltage and operated on an ungrounded circuit which is individual to the locomotive. The control is extremely simple, since there will be neither series-parrallel switches nor starting resistances necessary. This reduces the amount of control apparatus very greatly and thus not only reduces the weight, but the cost of the equipment.

While none of these locomotives has been completed, the indications are that this type of locomotive will have an important place on alternating-current railways.

Discussion

It will be noted that in the list of locomotives that has just been described there are three types of driving motors, several types of mechanical parts, and three distinct types of drive. For all of these differences there are good reasons.

All of the direct-current locomotives listed except the Paulista passenger have axle-hung, direct-geared motors. Axle loadings are limited to approximately 40,000 lb., motors are correspondingly light and speeds are moderate even for the passenger locomotives. For such conditions, the axle-hung, direct-geared motor with flexible gears is eminently satisfactory. The direct-current motor lends itself especially to this construction on account of its high weight efficiency and relatively small dimensions, which make it adaptable to any form of drive.

The New Haven alternating-current-direct-current locomotives listed have twin motors and quill-geared spring drive. These locomotives also have comparatively light axle loading, coupled with high speeds. On account of the weight of the motors and the high speed, spring-supported motors were required so the quill-geared type was adopted some years ago and has become the standard of the road. The same motors, quill drive, wheels and axles, are used on their 2–4+4–2 passenger locomotives, their 2–4+4–2 freight locomotives and the 2–6–2+2–6–2 passenger locomotives.

Strange as it may seem, it was found that the use of a twin motor, i.e., a driving unit consisting of two motors in one frame, with both pinions meshing with the same gear, is more economical than a single motor, for several reasons:

1. The twin motor for this locomotive speed is lighter and cheaper than a single motor of the same output.
2. Only one gear is required for a twin motor, while twin gears are necessary for a single motor.
3. The two sets of armatures and fields of a twin motor are connected permanently in series so as to be equivalent to a motor of twice the voltage and half the current of a single motor. This cuts the sizes of switches and cables to one-half of those required for a single motor.
4. With the motors carried directly above the axles, the twin motors, being of small diameter and mounted side by side, do not extend so far above the floor line of the cab as the single motor and therefore leave much more space in the cab for the control equipment. This is very important where the locomotive is intended for operation on both alternating and direct current.
5. Another advantage of the use of the twin motors on this road is that the electrical design of the individual motor is exactly the same as for the multiple-unit car motors, so that the armatures and other parts are interchangeable.

The latest types of alternating-current locomotives built in this country, both for single-phase commutator-type motors and for induction motors, are those listed in the table for the Pennsylvania and the Norfolk and Western Railroads. Both have the 2-8-2 wheel arrangement and gear and side-rod drive, with the jackshaft located outside of the rigid wheelbase. These locomotives are both designed for the maximum permissible wheel loading, i.e., 75,000 lb. per driving axle. There are very good reasons for adopting gear and side-rod drive for these locomotives. As a matter of fact, a careful analysis will show that it is not only the best, but the only type of drive possible for these locomotives after the general arrangement and type of motors and number of axles had been determined.

In the case of the Pennsylvania locomotive, the power required per axle was entirely too great for any single-phase motor that could be geared to an axle. The motor has a continuous rating of 760 h.p., at 23 m.p.h. This is the amount of power required for each driving axle. The motor is both too large and too heavy to have one side suspended on the axle and geared to it. The output is too great for a twin motor geared to the quill to develop, as it would require a pair of motors, each having 8 or 10 poles and a quill drive much heavier than any that has yet been attempted to develop the required power.

Motors driving through side rods and jackshaft only would have a prohibitive weight and dimensions so that there was no alternative to gears and side rods, even if this type had not been preferred. As built, the locomotive is wonderfully simple and compact for such a large output. Like all other locomotives built by the Pennsylvania Railroad, it is probably the largest of the type that can be built. The total weight on driving axles of 300,000 lb. is well proportioned to the tractive effort, which is 50,000 lb. continuously and 100,000 lb. maximum, as it requires 16⅔ per cent adhesion at continuous rating and 33⅓ per cent at maximum. As it stands, the locomotive is an example of symmetrical design, beautiful lines, and a minimum number of parts for such a large output.

There are other reasons for the use of the 2-8-2 type of locomotive for the Norfolk and Western Railroad. The three-phase induction motor is much smaller for a given output than the single-phase commutator-type motor. An induction motor large enough to develop all the power required for a single axle could have been built and geared directly to the axle, but in this case the four axle-hung motors would have been heavier and would have cost more than the two which were adopted. There is another reason which is still stronger. Induction motors run at an approximately constant speed. They are regulated by liquid rheostats in the secondary circuits of the motors. A separate rheostat is provided for each motor and it is desirable to have an ammeter for each motor in front of the motorman, so he may adjust the loads during acceleration and when there are variations in wheel diameters. Hence, the fewer motors and driving units there are, the less will be the total weight of motors, the simpler and lighter will be the control, and the easier it will be to balance the loads on the motors. Where induction driving motors are used, therefore, practically everything is in favor of using the smallest number of motors possible and this naturally leads to the use of side rods.

Considerations of Type of Drive

It will be seen from the foregoing that there are good reasons for the selection of the type of drive for all of the locomotives in the list.

In general, it may be stated that the choice of drive and the wheel arrangement, which together practically determine the entire design, will depend, first, on the class of service, i.e., whether it is freight or passenger, slow, medium or fast, light or heavy, the permissible wheel loading, track alignment, etc.; second, on the kind of driving motor that is to be used, i.e., whether direct-current, single-phase commutator-type, or three-phase induction; and third, on the judgment of the engineers who direct the design.

It is taken for granted that everyone is striving to secure a locomotive that will in the last analysis show the greatest economy in operation; i.e., one which will give the lowest total cost per ton-mile. It seems to be natural for everyone to assume that a locomotive that has the maximum power concentrated in a single unit on the minimum number of driving wheels will necessarily produce this result. That this is true in the case of the steam locomotive, the author has no desire to question, but he-believes that the electric locomotive introduces factors that make it necessary seriously to consider this point in each case. One of the principal reasons for the use of the maximum size of locomotive with a steam engine has no application at all on the electric locomotive. That is the cost of engine crews, since by the use of multiple unit control it is everyday practice for one crew to handle as many motive-power units as can be desired at one point in the train. Where a very heavy locomotive is required, the capacity of motive-power units should therefore be selected from the points of view of convenience, first cost, and operating cost, with due consideration to the effect on track and bridges.

One of the first points to be settled which is dependent directly on the service required of the locomotive is the total tractive effort which is required under maximum conditions. This ordinarily will determine the total required weight on the drivers.

The next question is the number of driving axles. This will be limited by the permissible axle loading, but will also depend somewhat on the permissible wheelbase and the type of drive which is preferred; also on the most economical size and number of motors to be used. The question of guiding trucks will depend largely on the class of service for which the locomotive is to be used, the length of rigid wheelbase and the speed of operation.

Since the locomotive is composed of so many different elements, it is obvious that no one feature should control the entire design if it is going to handicap the other elements by so doing. For instance, if a certain mechanical design is a handicap to the motors, it should be avoided if possible. Conversely, if a certain type or size of motor is a great handicap to the mechanical design, it should be avoided. The final design should be the best compromise of all the conflicting elements that can be secured.

It is desirable to have all parts that are subject to rapid wear easily accessible for inspection and replacement. It is particularly desirable to avoid crowding, which makes it difficult to remove any piece that is to be overhauled.

Careful consideration should be given to the relative economy of the maximum weight per driving axle with the largest size of motors compared to more motors and lighter axle loading; also to the relative ease of overhauling and the facilities required.

The author appreciates that there are not yet sufficient data available to make anything more than a few general statements in regard to these points, but he feels that the subject is one of such importance that it should be very carefully studied. The very active interest that is now aroused in railway electrification will naturally result in further engineering analysis of this subject, so that during the next few years many conclusions may be developed.

In conclusion, the tendency in heavy locomotive design for freight use sems to be toward the use of maximum axle loadings and transmission by gears, jackshaft, and side rod from motor to axles, together with the combination of the cab with the side frames. There is also a noticeable tendency towards the use of the individual drive with spring-mounted motors for higher-speed locomotives of large capacity. For locomotives with small capacity and axle loading with direct-current motors, the axle-hung motor certainly has the field.

Daily Locomotive Performance in Slow and Fast Freight and in Yard Service*

By R. S. PARSONS, Regional Vice-President, Erie Railroad

From a comparatively simple machine of 100 years ago, we have evolved a monster, draped with some 15,000 parts, each of which must be transported up and down the railroad, inspected with untiring regularity and many replaced frequently. These monsters, ranging from 200 to 400 tons in weight, do well if they drag three or four times their weight of paying freight on a comparatively level road. If efficiently handled, a locomotive may earn in gross revenue a little more than its cost in a year. What more necessary, therefore, than to schedule it, program it, baby it, belabor it, cajole it, and possibly marry it to some good engineer?

A 24 hour program for a modern railway locomotive is not unlike the daily routine of the average working man. Statistics carefully prepared by many of the larger railroads indicate that only about one-third of the life of the average engine is actually spent in productive work—that is, in moving cars. This makes it apparent that locomotives as well as the working man are strong advocates of the eight-hour working day. The enormous investment in locomotives necessary to maintain sufficient power so as to move the maximum business makes one of the first duties of successful management the maximum utilization of every engine. The business of the railroads has always been of a seasonal nature in spite of all efforts to overcome this by attempting to move company material, fuel coal, etc., during the months of light traffic. This of necessity means that during certain months many locomotives must be "white-leaded" when there is no productive service for them to perform. In only a few isolated cases is it possible for one railroad to advantageously transfer its power to another line. When one realizes that the average locomotive represents an investment of $65,000 or more, and that most railroad statistics indicate that but one-third of its time is actually spent in moving cars, it becomes readily apparent that there is an opportunity for marked improvement.

The Shops

Approximately 40 per cent of the locomotive's time is spent with the mechanical department, caring for running repairs, turning, its monthly boilerwash, and its annual vacation of 20 to 30 days is spent in the back shop. The engine, however, utilizes the vacation period to a better advantage than most of us, and is ready for another year's service. After consideration is given to the time elapsing between the time the engine is O. K.'d by the mechanical department and the time it is actually ordered, it becomes evident that about 50 per cent of the engine's time is actually spent on the division, although during only one-third of its time is it actually hauling cars. This period extends from the time the engine is ordered until such time as it is again delivered to the mechanical department at the next terminal after its day's work is done. When a 24 hour period is considered, it may also include a portion of the time spent on the return trip. From a purely operating standpoint we are interested principally in the

*A paper read before the Central Railway Club.

time the engine is available for productive service, and we desire that during that period it shall haul the maximum tonnage at a minimum cost.

The operating department expects that the engine will be delivered to it in 100 per cent condition. The mechanical department judges the engine by the locomotive miles; the operating department by gross ton miles. When it is repaired by the mechanical department, it is expected that it will be in just as good condition as when it was originally placed in service. The average life of a locomotive in freight service is from 15 to 20 years, and if proper care is given in replacement of the parts, it should constantly give satisfactory service. During recent years locomotives have ordinarily been retired on account of constant changes in operation, resulting in changes in design and size, making an engine obsolete far before the time it was actually worn out in service.

Slow Freight Service

When an engine is ordered for slow freight service, care must be taken to make certain that it is ordered at such a time as not to interfere with fast freight schedules, or passenger trains. If this is not done, it will mean excessive delays at the terminal and on the road, keeping out of the way of superior trains. In all cases the train should be ready and the chief dispatcher should be able to rely upon figures given by the yard so that the time the train is ordered to depart will coincide with the time it is actually leaving the terminal. The engine crew ordinarily comes on duty about 15 minutes before the train crew, giving the engineer an opportunity to look over the engine and "oil around" while the fireman is getting his tools and assisting in the inspection of the engine. Upon arrival at the yard the engine is backed onto the train. The air has already been tested by yard forces by use of a test engine or ground hose. The caboose is on the train; the conductor has his bills, as the train has been checked by yard forces, and as soon as the air is cut in, and the inspectors complete the inspection, the train is ready to depart. If there is to be successful road operation, it is essential that the inspection by car forces has been carefully made, as any car failures will certainly mean delay, and may result in serious accident.

Under normal weather conditions, trains can ordinarily depart from the yard without assistance, although when weather conditions are bad, it is well worth the investment for a yard engine to assist them in getting under way when leaving the terminal. When actually on their way the time in which they will reach their terminal is largely dependent upon the efficiency of the train and engine crew, and the skill of the dispatcher. The best engineer cannot make a good run if the dispatcher insists on his spending considerable time in sidings. The best dispatcher cannot get a train over the road quickly if the engineer consistently fails to make average running time between stations. On most divisions of average length, with the type of power now in use and with a tonnage train, it is necessary in some cases to take coal at an intermediate point. This is largely dependent upon the delays that are experienced. The necessity for taking coal in each individual case should be a subject for investigation. Taking coal with a modern plant should not consume more than five or six minutes, and there should be facilities so that the engine can take water at the same time.

It has been estimated that an engine consumes one-third as much coal when standing as when running, and in addition thereto it has further been estimated that it costs $1.75 to stop and start a tonnage train, not taking into consideration the wages of the crew. All of these factors make it apparent that successful and economical operation is dependent upon eliminating unnecessary stops and getting trains to the next terminal in the shortest possible time, not forgetting, however, that these trains must handle their full rating. On some divisions it is the practice for several trains to do work at intermediate stations; picking up and leaving cars should, as far as possible, be confined to the fewest number of trains to get a successful operation. When many trains do work at stations, it congests the railroad and results in delays to all trains as well as in many cases necessitating paying the crew penalty wages, commonly known as "pick-up rate."

If the factors mentioned above, namely—first, ordering trains at proper time; second, eliminating yard delays; third, proper preparation of trains by car inspection forces; fourth, good dispatching; fifth, elimination of intermediate work, are given consideration, there is but one other important factor in getting the train to its terminal. This is the engine and train crew and their attitude toward their work as well as their ability.

The engineer has served his apprenticeship as a fireman. If he has been interested in his work, he is familiar with all of the details in the construction of the engine. If the engine is assigned, he feels the same personal interest in it that he would in his automobile and is just as jealous of the care which is given it. In spite of all of the arguments that have been made against assigned power, it has been demonstrated on certain divisions that assigned power means reduction in shop expense, increase in engine mileage, and reduction in overtime. The principal argument against assigned power is based on the statement that an assigned engine can make but 2,800 or 2,900 miles per month. On the division to which we refer, engines in assigned service have made as high as 3,700 miles during one month and have been kept out of the shop twice the period ordinarily provided in the shop program. Engineers have kept the same engine for a period of six years and longer, and know just how to get the best results from it. It is common knowledge among railroad men that two engines alike in design and from a mechanical standpoint apparently similar in every detail, will give different efficiency.

The engine should be as nearly as possible in perfect mechanical condition when leaving the shop. This will relieve the engineer so that he may devote his time to observance of signals and the various rules relative to the use of whistle, bell, etc. The mechanical department is to a large extent dependent upon the work report prepared by the engineer, as many defects cannot be readily noted except when the engine is in motion. When the engineer takes a personal interest in his engine, he makes certain that all of the work is reported and is very insistent that the work which has been reported is actually performed. A good engineer not only has mechanical ability and experience, but is also interested in his work to such a degree that he will familiarize himself with at least a few of the many pamphlets or books which have been written on handling locomotives and on locomotive problems.

It is to be regretted that the tendency of the labor organization has an inclination to discourage the engineer from gaining a closer intimacy with the complicated machine which he is supposed to control. The engineer should represent a highly developed mind reposing in the brain cavity of a leviathan.

I had intimate knowledge of a passenger engineer who was so wedded to his engine that he made three times the mileage between shoppings that was the average on his division. He always maintained the privilege of selecting his own fireman, and this fireman assisted him in maintaining his locomotive in a 100 per cent condition. One qualification necessary for a fireman on this particular engine was that he should be satisfactory to the engineer.

The fireman can prove himself an economical or a very expensive man. A locomotive cannot economically consume more than 80 pounds of coal per square foot of grate surface per hour. Some firemen fire too heavy, resulting in the steam pressure doing down and a large portion of the fuel being wasted. All of these matters as to fuel consumption are of primary interest to the operating department, as the pounds of fuel burned per gross ton mile is a good index of operation. While the fireman must of necessity have certain preliminary education, he need not when first employed know the engine in detail. He should, at least, have more information than the first American negro fireman whom history charges with being responsible for the explosion of the first American locomotive on account of sitting on the safety valve. A fireman should never be employed unless he intends to advance in engine service and eventually become an engineer. The new fireman is at best an expensive man and the railroad can only hope to make good on its investment by educating him so that he can eventually fire economically.

Fast Freight Service

An engine in fast freight service performs much the same routine as that in slow freight service. On many railroads a lighter and faster type of engine is used for fast freight service, although this is not always the case. Where special types of engines are used, their mileage will be limited as they must be held to protect the schedules. On the division to which we have frequently referred above, the same type of engine is used on both fast and slow freight service. When used in fast freight service, it is ordinarily given 75 per cent of full rating. With this tonnage, it is expected to make a 106 mile division in 4 hours and 30 minutes. This division has two short stretches of single track and two helper grades. Engineers have been known to make this trip in 3 hours and 45 minutes, although such a run is exceptional. The engine in fast freight service frequently finds its train waiting for it on the main track as it has not been necessary to handle it through the yard. This method is taken to expedite the movement. If the train is ahead of schedule, it should be given more tonnage so that the operating expense may be kept as low as possible. If behind schedule, its tonnage should be such as to permit it to make up its pro rata of the lost time based on ultimate destination.

Fast freight service is at best a necessary evil from the standpoint of the operating man. It increases his cost, while he is given no credit in the way of increased revenue. In many cases, fast freight service is necessary on account of the perishable nature of the commodities, and in other cases it is desirable from a traffic standpoint. In some cases the privilege is unquestionably abused. If the operating man is successful in reducing his yard and road delays to a good figure, he can get a car in slow freight service over the division quickly enough so that the patron will be satisfied and will not be demanding fast freight service as given by a competing line. The fast freight service is only of value as schedules are maintained. It, therefore, becomes apparent that in handling fast freight both in the yard and on the road, this must be the first consideration—namely, that there is a fixed schedule which is to be maintained. Maintaining fast freight schedules the same as passenger schedules becomes largely a matter of habit and morale. If the men realize that the schedules must be maintained, and if they are given fair operating conditions, they will do so.

Yard Service

In most cases an engine used in yard service is a road engine which is no longer considered economical in road service. The pony truck has been removed and the wheels spaced so as to give proper balance. Undoubtedly more economical yard operation can result from engines especially constructed for yard service, but the average yard is at the mercy of the road in this respect and is somewhat similar to the younger brother who must wear the older brother's cast-off clothes. The yard engine ordinarily works two or three tricks before going to the roundhouse for running repairs, cleaning fire, etc. This means that yard crews change off on the job, therefore minimizing any delays in going to and from the roundhouse. If the location of the roundhouse will permit, the yard engine is moved to and from that point by a hostler who brings the relief engine to the yard.

Yards are a necessary evil, and in general are non-productive. They have practically no direct earnings other than a few switching charges and revenue incidental to diversions, etc. This means that to get an economical operation, as far as possible, trains should be kept out of the yards by properly classifying them at the larger terminals and that when a train is of necessity yarded it should be disposed of as quickly as possible. The method of switching employed is dependent upon the physical layout of the yard. The most common and at the same time most expensive operation is what is known as "flat switching." The use of pole cars, which was at one time the principal method of switching in American yards, has given way largely to the use of elevated hump yards. Without question the hump yard is the fastest and most economical method of switching which has yet been devised, especially if there are sufficient classification tracks of proper length as well as a receiving and departure yard, thus preventing delays both to road and yard power. In most yards, certain engines are required to perform industrial switching, placing and removing cars from private tracks and there are also numerous other duties such as pulling the cripple tracks, caring for the freight house and team tracks, handling cabooses, etc.

It is readily apparent that it is advantageous from the engineer's standpoint to work the yard engine in forward motion, and this is done wherever the layout will permit. Most yards have grown rather than being built and planned. They are as impractical in their design as the street layout of the average eastern city. They were originally built for a business which is but one-tenth, or even less, of present requirements. This has necessitated constant building of new tracks by succeeding generations of operating officials and no one plan has been used. It is the ambition of every operating man that he at some time may have the privilege of constructing and operating his conception of an ideal yard. The yard engineer and remainder of the yard crew also have their ideas as to what features should be included and what excluded. In most cases, however, it is possible by proper arrangement and scheduling of yard work, proper co-operation between the yards at different terminals and systematic ordering of trains as arranged between general yardmaster and chief dispatcher, to have the daily routine of the average yard engine performed at a minimum cost with a maximum number of cars handled.

Discussion of the Mechanical Features by Mr. J. F. Jennings of Detroit

The daily program and performance of both fast and slow freight engines as well as switch engines will, of course, depend upon the requirements of the service in the particular district to which assigned, the ideal program contemplating an even flow of business over each weekly period and at the same volume daily.

Unfortunately this condition exists only in rare instances and as a rule the operating department is called upon to move a vast volume of traffic certain periods in the week, and which gradually tapers down with the result that the locomotive department cannot figure on a reduction in the number, not only of road engines, but switching engines as well, that would reduce the unproductive time, but must keep enough in the service to meet the peak requirements. Where the demand for power is not constant it is the practice to hold the engines requiring, comparatively speaking, heavy running repairs and place them in such condition as will insure a first class performance. Very few roads differentiate in the class of power used in fast freight and slow freight, preferring to have power designed to meet both requirements rather than to specialize and therefore I have considered fast and slow freight power jointly.

The main essentials to good locomotive operation and performance on a daily program basis being:

The lengthening of freight divisions where possible, and in this regard a careful study made as to proper location of coaling stations enroute where a supply can be obtained readily and at points that will serve not only fast freight, but drag freight requirements as well. The proper location of track pans or water spouts in accordance with changes in operation. While these may appear as operating conditions they have a decided bearing on the service that can be given by the locomotive department with respect to the filling of lubricators and grease cups, cleaning of fires and minor touches that contribute to the success of the trip.

Maintain the minimum number of freight and switch engines in the service to insure the unproductive time being cut to lowest point possible consistent with good service, and yet to provide sufficient power so that same can be held for work, washout, etc.

Check the power situation daily with operating officials in order to determine not only as to their needs, but also with respect to movement of engines to a point where maintenance can be taken care of and avoid long layovers at points where repairs cannot be consistently made or at points where a large force is not maintained.

Educate the enginehouse foreman and engine dispatcher to listen attentively to the remarks of the enginemen with reference to the condition of the engines, and profit thereby not only in the work to be cared for, but the dispatching of the very best power on fast freight trains. The good points of a particular locomotive are not booked, they are discussed, and in selecting power for fast freight the opinions expressed by enginemen as to the qualifications of certain locomotives can well be taken into consideration.

It is regrettable that the greater number of engineers are gradually drifting away from the responsibility of reporting work on engines and leaving it all, with the exception to those items pertaining to their personal comfort, to the enginehouse inspector. An intensive program of checking negligent engineers by the master mechanics and road foremen of engines would have a very beneficial effect in the maintenance of power and a consequent improved daily performance.

The physical characteristics of the road will, of course, have a bearing on the program of not only fast, but slow freight engines as well, and what would appear feasible on one road would not work out satisfactorily on another, and the same would hold true on the consolidation of two or more operating divisions on the same railroad.

About the only daily performance for fast and slow freight engines to which I could refer with full knowledge would be that on the road on which I am employed—the Michigan Central. In operating locomotives through over two freight divisions on that portion of the road in the United States, designated as the east and middle divisions, it resulted in a mileage of approximately 177 miles, if dispatched Detroit to Jackson, thence Jackson to Niles by what is known as the Air Line, or 184 miles, if dispatched direct Main Line. The freight division on what is known as the west division was not disturbed, as it is practically 100 miles, Niles to the Chicago district, the originating point for our freight traffic, and a smaller class of engines can handle a favorable tonnage between Niles and Chicago.

Mikado type locomotives, with a tractive effort of 56,100 pounds and 59,000 pounds, respectively, are operated Detroit to Niles, with the maintaining point at Niles, the crews changing at Jackson in both directions, and in fast freight service negotiate the trip, Niles to Detroit, in approximately six hours with a train of 60 cars or 2,600 tons. All fast freight eastbound being dispatched by the Air Line on which water pans are so located as to meet the requirements and a coaling station at Wasepi 45 miles located adjacent to the main track about midway of the 104 mile division where all engines are coaled, the supply taken being sufficient, under favorable weather conditions, to complete the trip to Detroit, this due to favorable grade conditions eastbound, although, if necessary, engines can be coaled and fire cleaned at Jackson, 72 miles from Detroit.

The slow freight program is about the same except that it is necessary on the eastbound trip to obtain a coal supply at Wasepi and Jackson and in practically all cases to clean the fire and fill the grease cups at Jackson, the slow freight trip consuming about 12 hours from Niles to Detroit with a train of 90 cars or a tonnage of approximately 3,700 tons, pushed service being furnished for full tonnage trains eastbound out of Niles and Jackson. On arrival at the opposite terminal fires are dumped, flues given attention, a very careful inspection made of the machinery and all running work is attended to and engine then O. K.'d to operating department for return service.

The westbound movement in fast freight service presents a different locomotive operating condition, as the grade conditions from Detroit to Jackson are such that it is necessary to coal the engine and in some cases to clean the fires at Jackson, after which as a rule a train is dispatched via Main Line to Niles, this due to traffic conditions on the Air Line, which is a single track division. Track pans are conveniently located and a very modern coaling station extending over the tracks at Augusta, 55 miles from Jackson, serves the fuel requirements. Fast freight trains, Detroit to Niles, negotiate the trip in nine hours with a train of 80 cars or a tonnage of 2,700 tons, while slow freight trains require about 14 hours with a train of 90 cars or a tonnage of 3,200 tons. Pusher service of full tonnage trains is furnished over the ruling grades westbound out of Jackson and Kalamazoo.

On the Canada Southern division, Windsor to Montrose, with Windsor the maintaining point, the fast and slow freight engines operate over a 220 mile freight division with engine crews changing at St. Thomas about midway of the operating division, coaling stations and track pans being so located that all requirements are satisfactorily served, but owing to very favorable grade conditions a smaller class of freight power serves the purpose.

The locomotives are cut out at the maintaining points at washout periods and at any time when necessary on account of repairs, the frequency of the washout depending, of course, on the water conditions. With prompt handling at opposite terminal from maintaining point and favorable traffic conditions pool engines negotiate between 4,000 and 5,000 miles per month.

In the daily program and performance of a heavy switching engine it has been found feasible to adopt what is known as the group plan, assigning as many three-crewed engines as the service will permit and providing one extra engine for each five so assigned, the hostler relieving these regular engines and returning them to the enginehouse for cleaning of fires, daily inspection and repairs, so that the actual period in continuous service of any group without having fires cleaned will not exceed 16 hours. With this plan it is possible by supervising the changes to attend to washout, Federal requirements, etc., without disturbing the regular assignment to any extent. Where the volume of business is not continuous and there is a reduction made in the total number of engines or crews assigned during the weekly period, it has been found possible through the group plan assignment to take care of the heavier running repairs without increasing the number of engines assigned to any one yard.

An engine in heavy switching service to give a good performance should have the fire cleaned each 16 hour period. In our Detroit yards a careful study was made of the conditions, and at what might be termed yard strategic operating points a two stall engine shed capable of housing four engines, a modern coaling and sanding station, suitable clinker pit and the necessary buildings for supplies, register and locker room for enginemen were erected, which provides an ideal arrangement. Any minor repairs can be readily cared for at these points and engines tied up and dispatched without the serious delays met with in negotiating a daily trip through a congested yard to some central point.

At washout periods or whenever necessary in order to properly take care of running repairs, engines are changed off by hostlers or relief crews and taken to the maintaining enginehouse for attention. The prompt handling of the engine from the time of arrival on the cinder pit until engine is housed has a very decided bearing on the daily performance on all classes of power, therefore, suitable track arrangements, modern coaling and sanding stations and labor saving devices are essential. To illustrate the point—during the extremely cold weather experienced last winter it was found that through the use of a comparatively inexpensive oil torch the time consumed in dumping fires on engines arriving at the pit with ash pans filled with frozen cinders could be reduced from approximately 1 hour and 30 minutes to 30 minutes. This represented unproductive engine hours to the locomotive department which were readily transferred as productive hours to the operating department.

Meeting of the Pan American Railway Committee

The Pan American Railway Committee, reorganized by the Governing Board of the Pan American Union in accordance with the terms of a resolution adopted at the Fifth International Conference of American States held in Santiago, Chile, in 1923, met for the first time at the Pan American Union on Monday, July 7th. The meeting was attended by Sr. Dn. Santiago Marín Vicuña, of Chile; Sr. Dn. Francisco P. de Hoyos, of Mexico; and Mr. Charles M. Pepper, of the United States. The Director General of the Pan American Union, Dr. L. S. Rowe, was also present.

The Committee adopted a resolution expressing appreciation of the work accomplished by the original Committee and of the efficient manner in which it had performed its labors. A resolution was also approved requesting the Pan American Union to obtain all the available information from the Governments of Latin America relative to railways in the respective countries, this information to be made the basis of a report to the Committee at a meeting to be held in 1925, possibly at Buenos Aires, Argentina.

One of the first subjects that will receive the consideration of the Committee is that of the route of the railway that shall unite New York and Buenos Aires. The original report of the Intercontinental Railway Commission, created by the First International Conference of American States, recommend that the line, after passing through Mexico and Central America, should traverse the western highlands of South America until it reached southern Peru, where it should turn southeastward through Bolivia and Argentina. Within recent years, however, considerable attention has been given to plans for a line passing east of the Andes and avoiding the mountainous regions.

The route originally mapped out by the Pan American Railway Committee called for the construction of a line from New York to the Mexican border, through the Republics of Mexico, Guatemala, Honduras, Nicaragua, Costa Rica, Panama, Colombia, Ecuador, Peru, Bolivia and Argentina to Buenos Aires, with extensions from the main line to those countries not in the direct path of the railway. Of this distance of approximately 10,116 miles, 6,696 miles will have been built upon completion of the section now under construction between Atocha and Villazon, in Bolivia, leaving 3,420 miles unfinished. The greatest gap in the system is in the region between Panama and Lake Titicaca, a boundary lake between Peru and Bolivia, where approximately 2,820 miles yet remain to be built. This territory is very mountainous, making it extremely difficult to construct railways, and it is for this reason that changes in the original route have been proposed. According to these projects, which differ only in minor details, the railroad constructed over the new route would avoid the mountainous region along the Pacific coast of South America, and traverse the interior passing through western Brazil and entering Bolivia on the northeast.

Rail Salaries Small Part of Revenues

The aggregate sum paid to railroad executives in salaries is equivalent to a salary of $4,000 a year to the executive of a corporation doing $6,400,000 worth of business a year. These figures are derived from commission reports and from material filed from time to time with the United States Senate relative to alleged "fancy salaries" paid railroad executives.

What these figures show is briefly as follows:

The railroads had operating revenues in 1923 of about	$6,400,000,000
The salaries of their presidents amounted to about	$4,000,000
Reduced to terms of a smaller business, this is equivalent to a corporation doing a gross business in a year of	$6,400,000
Paying its president a salary of	$4,000

This sum is much lower than is paid in other businesses for corresponding ability and responsibility.

If all the general officials and their assistants, together with all the division officials and their assistants, in fact all of those in official position of any character in the management of our railroads (and who receive less than 3 per cent of the money paid by the railroads for labor) were discharged, the savings would not be sufficient to enable the roads to reduce their freight rates 1 per cent.

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Locomotive and Boiler Accidents

At the last meeting of the Master Boiler Makers' Association Mr. A. G. Pack, chief inspector for the bureau of locomotive inspection of the Interstate Commerce Commission, delivered an address in the course of which he called attention to the changes that had taken place in locomotive power, conditions and accidents during the past two decades.

According to Mr. Pack the number of locomotives in use in the United States has increased 50 per cent in that time, while the total tractive effort has increased by about 160 per cent. This latter has been obtained by an increase in the size of the boilers and the addition of many new appliances. In later years the percentage of increase of tractive effort over number of locomotives has been much greater. For example, during the past eleven years the numbers have increased 12 per cent and the tractive effort 58 per cent, and during the past 5 years the increase in numbers has been 2 per cent with an approximate increase of tractive effort of about 12 per cent. All indicating a rapid increase in the size of the locomotive.

At the present time there are 70,670 locomotive boilers that fall within the jurisdiction of the law, of which about 5,000 have been built within the past 15 months, with about 9,270 that are twenty-five years or more of age.

About 58 per cent of the boilers now in use are equipped with arch tubes and more than 34,000 are equipped with superheaters.

The increase in the size of and pressure carried by locomotive boilers has had a marked effect on the results of locomotive failures. For example, during the first six years that the locomotive boiler inspection law was in effect, the average number of persons killed per 100 crownsheet failures was 51, while, during the past six years it has been 71, or an increase of about 40 per cent.

Starting with 1912, when there were 856 accidents due to boiler and appurtenance failures in which there were 91 people killed and 1,005 injured, there was a steady decrease to 1922, when there were 273 failures with 25 fatalities and 318 people injured. Then, in 1923, these figures rose to 509 accidents, with 47 fatalities and 594 injured. This increase is attributed to the "unfortunate" strike of 1922, as the result of which the railroads lost a large percentage of their well-trained, experienced and capable mechanical employees, and this resulted in defective conditions.

Defective conditions are reflected not only by the number of accidents and casualties to persons, but by the number of locomotive failures on the road.

Crownsheet or firebox failures are the most prolific sources of serious and fatal accidents which can be caused by boiler failures.

During the year 1912, the first year that the locomotive boiler inspection law was in effect, there were 94 firebox accidents, resulting in the death of 54 persons and the serious injury of 168 others. This rate fluctuated through the succeeding years, but with a general downward tendency, until in 1922 the number of accidents had been reduced to 32, which resulted in the death of 22 persons and the serious injury of 55 others. This reduction in the number of accidents shows without question the result of better inspections and better repair of fireboxes, feed water appliances and water indicating appliances, as well as the locomotive in general.

It is generally well recognized that locomotives and locomotive boilers with the appurtenances, which contribute to the cause of these accidents, were maintained during 1922 at a higher standard than had obtained for a number of years and probably better than ever before. This reduction in the number of accidents was brought about notwithstanding an approximate increase in the number of locomotives in use by about 11 per cent and the fact that locomotives had grown in size and complexity to such an enormous extent during recent years.

Government Operation of Railways Not Satisfactory in Sweden

Government ownership and operation of the railways in Sweden has not proven satisfactory and as the result of study made by a special committee, the government will consider retention of ownership, but that operation be placed in the hands of an assembly of 29 members co-operating with a board of 7 directors.

The Assembly composition is as follows:

Composition of the Assembly	No.	Percent
A. Government	9	31.3
B. Riksdag	8	27.5
C. Employees	6	20.6
D. Public Traffic	6	20.6
Total	29	100.0

The Swedish Government owns their railways and operates them, but the results have been so far from satisfactory that they are seeking a solution of this difficult problem and the tentative plan submitted for consideration embodies many valuable points and suggestions that the advocate of government ownership and operations in this country might study with much profit and thus avoid the dangerous pitfalls in the path of what would at once develop into a most corrupt and unmanageable political machine.

Checks and Balances

The assembly it will be noted has 31.3 per cent government representation and while it could in combination with B., C. or D., have a majority, it must be also observed that B., C. and D. hold the veto power either in electing the 7 directors or in handling matters pertaining to administration of the property.

The Riksdag, which may be compared to our Congress, has 27.5 per cent and the employees 20.6 per cent representation. If these two fused for government operation their combined strength would only be 48 per cent, which would insure full consideration and fair treatment, but unless strengthened by aid from Class A or D would not be able to construct a political machine of their own design regardless of the rights or wishes of others with equal or greater interest. The public or traffic interests, that is the shippers who pay the freight, have 20.6 per cent representation in the assembly. In other words, the principle is recognized that with taxation goes representation and the industries which support the railways are to have a "Look In" as to the fairness of the charge for service, and incidentally what becomes of the money.

It will be interesting to observe the development to the final solution of the problem.

Fallacious Theories Exploded by Commissioner Potter in Rate Case

It has been quite clearly pointed out several times recently in *Railway and Locomotive Engineering* that: (a) the price of food and clothing was not controlled or even influenced to any extent by rates of transportation. (b) that over-production in any commodity forced prices down regardless of transportation rates. (c) and that if all food and clothing were transported *free*, the price to the ultimate consumer would be *no* less, to the producer substantially *no* more, but the railways would be *ruined*.

Notwithstanding we have so often taken the above position, and given plain every day examples of the extreme fallacy of those who have foolishly claimed that a drastic reduction in freight rates, which meant ruin for the railways, would bring prosperity to the farmers, we have not been able to announce concurring views of those in high and influential positions of authority as we felt the justice of the cause fully warranted. It is therefore a source of much gratification that we can reproduce the wonderfully clear, concise and businesslike reasons set forth in the concurring opinion of Commissioner Potter in the I. C. C. declination to reduce grain rates, which is as follows:

"No one may ask more than to have the aggregate burden fairly distributed according to the ability of traffic to bear it. To make possible and facilitate traffic movement is a sound principle of rate making. Grain and grain products are moving and would continue to move even under higher rates. It is not claimed that reduction would increase the movement of grain or its products.

Rate Reduction Would *Not* Help the Farmer

The most that is claimed is that producers would be benefited. It is by no means certain that this would result. The amount per bushel, or per one hundred pounds, involved in the reduction asked for, would be no more than current market fluctuations from day to day. The middleman or dealer might benefit *but not a penny would ever reach the producer.*

About 85 per cent of all the shippers pay to the carriers is used to pay operating costs and taxes. If the owners of the railways were to receive nothing for the use of their properties, which we have found worth more than $20,000,000,000 rates could not possibly be reduced under present conditions of high cost of every thing the carriers use by more than 15 per cent. A general rate increase which would assure a fair return to railway owners, improve railway credit, encourage betterments and expansion, and stimulate purchases, would help the farmer by increasing the demand for his products and improving the price which he receives. An increase would probably be the best thing that could happen to the entire country. A general decrease would be certain to bring disaster and the producers of agricultural products would suffer most.

Railways Not to Blame for Present Conditions

We are passing through a serious period in world affairs. Times are out of joint. Discontent breeds criticism. We are suffering an epidemc of selfishness, greed, high living, extravagance, and waste. Railways are kicked and cuffed because of habit and because they are within the reach of the discontented and disgruntled. The farmers and railways should pull together. Their interests are identical. They share alike in prosperity and adversity. Each class should do for the other all it can. They both suffer under low prices for what they sell and high costs for what they buy. Both are at a disadvantage as compared with practically every other industry. High costs of production and distribution hit them both alke. They should take up fundamental problems together and in co-operation. They should work with one another for mutual benefit.

The talk about the freight rates on farm products and the Esch-Cummins act as being responsible for, or having the slightest effect on, the condition of any part of the agricultural industry is a colossal exhibit of unsoundness and insincerity. We should say what the well-informed know, that they have not the slightest effect on the prices the farmer receives for his products. Haul them for nothing, and he would not be a bit better off. The most that is claimed for a reduction is that it would have what is termed a psychological effect upon the farmers. It is supposed he would think he is being benefited. The farmer would not be fooled very long by such deception.

Railways Not in Position to Try Expensive Experiments

It would be easy to become enthusiastic over the plan suggested by one of the dissenters to put such pretensions to the test if some honest way could be found to get the money to do it with. It is difficult to go along with a proposition to take this money from the railroads. Just how we are authorized to take away from them twenty or *thirty millions of dollars* a year to prove that some one else is wrong, and that after all the carriers are entitled to this money, I can not see.

Low prices are not in themselves the basis of distress in agriculture. They are results, not causes. The basic ill is overproduction. Correct that and prices will adjust themselves to a satisfactory level. As long as there is a surplus above the market needs the competition of producers for the market will force the prices down, no matter what the freight rate is, and even if it were entirely removed. If the farmers' dollar is not worth as much as other dollars it is because they have made it so by excess production. Their dollar is, in fact, worth as much as any dollar. The trouble is that competition among themselves forces them to give up too much for it.

Excessive Production, Not Freight Rates Is Cause of Wheat Growers Trouble

Over production is the instrument that does self-inflicted damage. This is the whole story and explanation of the wheat farmers' present plight. The country needs for domestic consumption and for seed about 600,000,000 bushels of wheat per year. As long as conditions remain as now in the foreign market a crop of that size will be worth more to the farmer than 800,000,000 bushels, and the cost should be from 15 to 20 per cent less. If producers are misled to excess production by expectation of a foreign market which is not realized, the railways should not be expected to bear their loss. Charges of carriers have been low when compared with other costs between producers and consumers. For furnishing cars, power, and for hauling and management the compensation of the railways averages about one cent per ton per mile of haul, and for that compensation they throw in a large amount of storage facilities for producer, dealer, and consumer. The charge of one cent per ton per mile is creditable when compared with a charge of $1 per ton per mile before the receipt or after the delivery of traffic by the railways. Nowhere else is so much capital and ability rendering such service for such small compensation.

When an agency of government is urged to take action to correct an evil, it is necessary to consider with what agency the duty lies. There is an evil and the farmer is the victim. The action necessary to correct it is not within our function. We have to do with transportation, and transportation is not at fault. The cause of distress is overproduction. As between the farmers and the railways, the farmers are to blame and have no right to call on the railways to bear the burden. There may be some one else to whom they have a right to look. The present condition of overproduction largely is due to the fact that during the war the farmers were induced to increase production in the public interest. Perhaps that fact entitles them to look to the public for fair protection and for some assistance in carrying the burden which the representatives of the public asked them to undertake. In that aspect it is not a question of price fixing or of interference with the laws of supply and demand. It is a matter of good faith and common honesty to do justice in a situation which may never occur again.

The foregoing fully endorses from all angles, the position which we have taken in this matter, and we hope that all our readers will not only study carefully the foregoing unanswerable logic and fundamentally sound reasoning, and use their best endeavors to have it brought to the attention of all those interested in the prosperity of railways and general welfare of the country.

Demagogues and uninformed persons in all walks of life who persist in their pernicious anti-railway propaganda should be relegated to obscurity, as a slight measure of retribution for injury they have done to those they profess to aid.

The Third Class in China

In a recent number of the *Atlantic Monthly*, D. C. Smith describes the condition of third-class travel in China as he experienced it on the Canton-Hankow Railway. He calls attention to the fact "that I not only mention the railway line but also make mention of the fact that I was in a third-class car. It is almost a hopeless task to explain just what that means. If you've ever been third class on a Chinese train you know something about it. If you haven't, it is very difficult to make you visualize it. My personal opinion is that the Canton-Hankow line is the worst in China. The third-class coaches on this division of the Chinese Government Railways are what might be called 'glorified freight cars.' The expression is hardly adequate because it implies rather too much. The 'glorification' amounts to cutting about a dozen holes in the sides of the cars to be used as windows, and putting benches along the walls, with double benches running down the centre of the car. Over each bench is a shelf, about eighteen inches from the top of the car. These are presumably for baggage. The rack in the middle is about three feet wide. At each end of the car is a door, leading into the next car, while in the middle of each side is a wide sliding door which provides the main avenue of ingress and egress for the car.

"In the winter time, when the car is unheated and drafty, and the roof leaks, and the windows are shut and the atmosphere reeks, it bears but little resemblance to any parlor car you have ever seen. And after all, you ought to take into consideration the fellow travelers who are apt to swarm into the car. Knowledge of the mysteries of bacteriology is possessed by none. Cuspidors are unknown. And —— but what's the use? The place becomes what you might call 'thick.'

"On the twenty-first of this month I was on the train, undergoing the twenty-five hours of travel which are required to complete the 225 miles of this trip. The car was as full as usual. The train when in motion, which was little enough of the time, swayed and rattled and jolted along at the breakneck speed of about ten miles per hour. Garlic, cheap tobacco, and the evident need of baths all around made free breathing rather difficult. Down at one end of the car a mother, dressed in blue coat and trousers, was nursing her young son who was still gay in the red suit which he was wearing in celebration of the lunar New Year. Sitting on the end of a bench, gazing pensively out of the open door, was a gray-clad soldier, shoeless, but bulging with his three or four padded coats. He nudged the farmer next to him, borrowed his cigarette holder, took a box of matches from the lap of a satin-gowned merchant across from him, and gravely lit up. The train jerked and halted to a stop and the air became filled with cries and curses as passengers near the ends of the car tried to fight their way through the crowd between them and the door, while a pushing, fighting mob attempted to force its way in at the same time.

"Was I being crushed under foot, buffeted about, dug with elbows and crushed by the ubiquitous bedding-rolls? I was not. In calm unconcern I glanced up a moment, gave an interested look or two at the fray, and returned to a perusal of 'A Conversation with Cornelia.' When the scene was reenacted at the next station, I gave it hardly more than a cursory glance, for I was deeply engrossed by the doings of the wily Sam. But lest you conclude that I must be either a liar or deaf-and-dumb, or both, permit me to explain the secret of this remarkable power of concentration. I was lying on my own unrolled bedding in the centre baggage-rack. The tumult and the shouting rose and died. The coolies and the soldiers departed and were succeeded by others of like kind. Tea was gulped and gurgled and the floor became unspeakable. But my magazine and I were above all that, and nothing disturbed us but the conductor and his five armed guards and two announcers who came for tickets and dragged me out of the fourth assembly of the League of Nations."

Brazilian State Ownership a Failure

A special cable to the Chicago Daily News states that the recent report of the British financial mission to Brazil, which recommended that the Bank of Brazil be removed from politics and that the Central Brazil railroad be sold to private interests has had a wide effect.

The Central Brazil railroad is a "white elephant" on the government's hands, says the cable. Showing constant financial losses, its expenses are about 15 per cent more than receipts. "Like everything else in Brazil that is subject to political control," reads the message, "it is inefficiently managed and its pay rolls are overloaded with names of political parasites."

Long Locomotive Runs*

By FRANK E. RUSSELL, Assistant Mechanical Engineer, Southern Pacific Company

We have read and heard more about long locomotive runs during very recent times than in past years, and as our ideas and thoughts are governed largely by comparisons, what would have been considered a long run two generations ago would be termed a very short run these days.

Shortly after the first steam locomotive was actually put in operation some of the enthusiasts, in discussing and writing about the possibilities of the new machine, became so visionary as to predict that at some day in the future the machine might be so perfected as to travel at the unprecedented speed of a mile a minute. On the other hand, there were many wise men of that day and age who contended it would be impossible for a human being to live traveling at that rate of speed, and furthermore, claimed that it would be impossible to build a machine which could run faster than 12 to 15 miles per hour and hold up under that service.

In order to appreciate the thought of the people at that time it must be remembered that their most rapid means of transportation was by saddle horse. We have since advanced from the small crude locomotives first designed for railroad transportation, to the huge modern locomotives of the present day. Paralleling this with other means of transportation, we have advanced from the one-horse shay to the luxurious automobile and aeroplane.

The development of the steam locomotive has kept pace with the development of civilization, for during a period of about 100 years or so—only somewhat longer than a human life—the steam locomotive has developed from a miniature crude machine, capable of little more than self-propulsion and running not over fifteen miles, to a huge, efficient machine capable of handling smoothly and easily luxurious passenger trains consisting of 12 cars weighing 875 tons over mountain, desert and plain at high speed for a distance of 815 miles. The existence of the locomotive corresponds to three generations and its development follows very closely the development of railroading which can also be divided into three characteristic periods. First. The period of railroad construction. Next, the period of expansion and rule-of-thumb methods. Then, the period of improvement in materials used and application of mathematical talent in computing stresses and proportioning parts.

The locomotives placed in service up to the year 1864 were of crude construction and wrought iron was the principal material used. They were not equipped with power brakes or any of the modern devices.

During the next period, 1864 to 1894, the principal changes in locomotives in this country were generally an increase in size, application of air brakes, automatic couplers, injectors and other appliances and the use of steel in construction.

During the period 1894 up to the present time we find new materials used and much improvement in design, also many new devices developed, not only increasing the power output and durability, but also very materially producing more economy and a higher efficiency. The most important of these devices are superheaters, feed water heaters, brick arches, boosters, improved valve gears, and improvements in air brakes and lubricators, all of which have a marked effect upon the distance over which the locomotive can be successfully operated.

There are many conditions under which a locomotive can be economically operated. The first and most important of these is the topography of the country which determines the gradient and curvature, making it necessary to change power to suit the grade conditions. To illustrate: Power suitable for economical operation on 2 per cent or 3 per cent grades could not be economically operated over a long distance of flat country where grades range from level to 1 per cent. Location or distribution of shop facilities where the necessary attention can be given locomotives at the end of run, the schedule of trains, junction points, water supply, etc., are also important factors.

The location of shop facilities is to a great extent controlled by the character of the country and operating conditions. In most cases these facilities were established many years ago when roads were built to suit the power and equipment then in use, and there is no question but that a great many locomotive runs could be extended more or less if we could easily move the shop facilities to take care of the power. This, however, would mean an expenditure of huge sums of money which could be used to better advantage for other purposes. Hence, it will be seen that under present day conditions, when terminals and repair facilities have already been located, it requires considerable courage on the part of the Motive Power and Operating Officials to extend locomotive runs, especially as they cannot readily increase the runs, say 10, 20 or 30 per cent, but must take a bold step and double or treble the distance. Thus, in referring to long locomotive runs they are generally considered to be such only when locomotives are regularly operated over two or more districts where the power formerly was changed. Individual long locomotive runs which have been made for advertising or spectacular effect are of no particular benefit to the art other than, possibly, to show what can be done and to encourage others to attempt running locomotives over long distances without change. The mere fact that locomotives may be successfully operated over an unusually long distance may not necessarily mean the most economical operation. The most important object in extending the length of locomotive runs is to increase their productive time or, in other words, obtain greater monthly mileage from the power.

The time locomotives are at terminals, in engine houses, etc., is non-productive time. Taking the Class I railroads in the United States during 1921, the average non-productive time of freight locomotives amounted to somewhat more than 17 hours out of 24; hence, the locomotives were idle and not earning two-thirds of the time.

Appliances and Improvements in Design Make Long Locomotive Runs Economical

The superheater virtually amounts to an increase in boiler capacity by adding additional heat units, causing an increase in volume of steam on its way from boiler to cylinders. This amounts to about 30 per cent; hence, a locomotive equipped with superheater can perform approximately the same work and the boiler only evaporate two-thirds as much water as a saturated steam locomotive. This in turn is equivalent to increasing tank capacity and reduces the amount of scale-forming matter deposited in the boilers over a given run. It also produces increased power at high speed and permits of operating locomotive at shorter cut-off. In addition to this, the superheater very largely overcomes carrying water over into cylinders which washes off lubricants, causing lubrication trouble.

**A paper read before the Pacific Railway Club.*

Feed water heaters help to make long continuous runs successful by diverting a portion of the exhaust steam, which would otherwise be wasted, to the boiler in the form of water. This amounts to about 10 per cent, thus making it possible to go somewhat further before taking water and reducing the amount of impurities admitted to the boiler. In addition, as the heat is returned to the boiler there is a saving of fuel, also an increase in boiler capacity. In diverting a portion of the exhaust steam to heat feed water a reduction is made in back pressure in the cylinders, which in turn increases the power output of the locomotive by probably 2.5 per cent to 5 per cent.

From this it will be seen that a modern locomotive equipped with these devices should be able to handle the same train for possibly 50 per cent greater distance without evaporating any additional water in the boiler. However, such devices, when locomotives are idle, standing at terminals, on sidings, etc., are not making these savings; hence, the importance of keeping them in use.

Brick arches and other improvements in fireboxes and boilers have done much to increase boiler capacity, fuel economy and reliability.

The booster in many cases will provide the locomotive with sufficient additional power to carry it over some controlling grade on the line, thus fitting the locomotive to the service and permitting its operation of the locomotive over a longer run than would otherwise be possible without the use of helpers . . . . The use of boosters in starting heavy trains on grade or slippery rail will usually prevent drivers slipping and spinning, which sets up severe strains in machinery and undoubtedly actually produces more wear than many miles of actual running.

Much improvement has been affected in recent years in hydrostatic lubricators for cylinders and air compressors. Also there are many mechanical lubricators in service which are giving very promising results. We have passed from oil lubrication of driving axles, crank pins and similar parts to grease lubrication, driving axles being equipped with automatic grease lubricators which require but very little attention. Various forms of grease or "dope" cups are used, which eliminates much of our former lubrication trouble.

Refinement in Design and Materials of Construction

By utilizing higher grade materials in the construction of locomotives it is possible to build locomotives with ample boiler capacity, sufficient strength in various parts, adequate bearing areas, and still keep within the weight limitations. Much has also been accomplished in recent years by improving engine trucks, trailing trucks and spring and equalizing systems, relieving the locomotive of unnecessary shocks and vibrations. A lateral motion device has been perfected for application to front drivers, which device can also be applied to other drivers if found necessary and which very materially relieves the stresses set up in long wheel base locomotives when taking curves. Vibration is probably the greatest single cause of failure and regularly exacts its toll of every piece of machinery in operation. One of the most important improvements in recent years that materially reduces shocks and vibrations has been accomplished by utilizing higher grade materials in conjunction with improved design in such parts as connecting rods, crossheads, piston rods, and pistons. The side rods and a portion of the main rod are revolving parts, and the others, such as front end of main rod, crossheads, pistons and piston rods, are reciprocating parts. The reduction in weight of both revolving and reciprocating parts materially reduces the wear on rod brasses and pins. The reduction in weight of reciprocating parts is one of prime importance for we know there is no other single feature that will cause more vibration and set up more destructive strains than counter-balance, either the lack of or too much of it. The revolving parts we can balance in all directions as both the parts to be balanced and the counterbalance have a rotary motion. With reciprocating parts it is different; they have a horizontal motion and the balance placed in wheel centers to balance them has a rotary motion; hence all weight placed in wheel centers to balance these parts is over balance in a vertical direction and produces a disturbing force on rail. With heavy reciprocating parts in common use 20 years ago, it was necessary to balance two-thirds of the weight of these parts. Reducing the weight of reciprocating parts to less than 1/160 of the weight of locomotives permits balancing only 50 per cent.

Weight of reciprocating parts, to one not familiar with the design and operation of locomotives, might appear somewhat insignificant. It is, however, of prime importance in making the locomotive a more efficient and durable machine. To illustrate this by concrete examples: On the Southern Pacific Company's new 4-8-2 type passenger locomotives, by the use of higher grade materials in conjunction with improvement in design, the following results were obtained:

Saving in Weight

Revolving parts. Side rods, 100 lbs., Main rod, 52 lbs.; main crank pin, 60 lbs. Total saving in weight of revolving parts, 212 lbs.

Reciprocating parts. Main rod, 42 lbs.; piston rod, 50 lbs.; piston, 75 lbs. Total saving in weight of reciprocating parts, 167 lbs.

Reduction in counter weight required, 202 lbs.

These figures are for one side of engine only, thus making a total saving in static weight on one side of locomotive of 581 lbs., or a total of 1,162 lbs., per locomotive.

Considering the saving in reciprocating weights, we balance 50 per cent of this weight in driving wheels to protect the machinery and reduce vibration, and

SOME OF THE LONG LOCOMOTIVE RUNS MADE ON AMERICAN RAILROADS

Passenger Service

Road	From	To	Miles
Southern Pacific	Los Angeles, Cal.	El Paso, Tex.	815
M. K. T.	Parsons, Kan.	San Antonio, Tex.	678
Union Pacific	Kansas City, Kan.	Denver, Colo.	640
Southern Pacific	Sparks, Nev.	Ogden, Utah	536
A. T. & S. F.	Winslow, Ariz.	Los Angeles, Cal.	602
Union Pacific	Council Bluffs, Ia.	Cheyenne, Wyo.	509
Union Pacific	Council Bluffs, Ia.	Denver, Colo.	562
Union Pacific	Denver, Colo.	Ogden, Utah	577
Canadian National	Montreal, Que.	Toronto, Ont.	334
C., M. & St. Paul	Milwaukee, Wis.	Minneapolis, Minn.	321
Great Northern	St. Paul, Minn.	Minot, N. D.	526
Great Northern	St. Paul, Minn.	Winnipeg, Man.	458
Missouri Pacific	Hoisington, Kan.	Pueblo, Colo.	338
St. L. & S. F.	Oklahoma City, Okla.	St. Louis, Mo.	542
Kansas City Southern	Pittsburgh, Kan.	Shreveport, La.	430
Spokane, P. and S.	Vancouver, B. C.	Pasco, Wash.	378

Freight Service

Road	From	To	Miles
Southern Pacific	Sparks, Nev.	Carlin, Nev.	387
Southern Pacific	Del Rio, Tex.	El Paso, Tex.	453
A. T. & S. F.	Los Angeles, Cal.	Needles, Cal.	310
Union Pacific	Ellis, Kan.	Denver, Colo.	337
Canadian Pacific	Calgary, Alberta	Edmonton, Alta.	180
St. L. S. F.	Memphis, Tenn.	Birmingham, Ala.	251
M. K. T.	Parsons, Kan.	Denison, Tex.	278
Union Pacific	Kansas City, Kan.	Ellis, Kan.	303
Grand Trunk	Ft. Erie, Ont.	Sarnia, Ont.	189
C., M. & St. Paul	Chicago	Nahant, Ia.	209
Great Northern	Havre, Mont.	Wolf Point, Mont.	202
I. & G. N.	San Antonio, Tex.	Palestine, Tex.	260
B. & O.	Cumberland, Md.	Parkersburg, W. Va.	205
B. & O.	Connellsville, Pa.	Willard, Ohio	264
B. & O.	Willard, Ohio	Chicago	278
Missouri Pacific	Downes, Kans.	Atchison, Kans.	208

permit 50 per cent of the weight to go unbalanced. The reason for this is a compromise between locomotive machinery and track.

By this saving of 167 lbs. in reciprocating weights we reduce the total thrust or pound on main rod brasses and pins at diameter speed on these locomotives a little over 8,000 lbs., or about 4 tons, which pound or thrust takes place twice in every revolution. With locomotive operating at 50 miles per hour this reversal of stresses occurs at the rate of 460 times per minute and at diameter speed, or 73 miles per hour, 672 times per minute, or over 11 times per second. In turn, the saving in thrust or pound on each side rod brass is a little over 2,000 pounds, or approximately one ton. At the same time there is a reduction in the disturbing force or dynamic augment on the rail of a little over 4,000 pounds on each side of locomotive, or about 1,000 pounds per wheel due to reduction in counterbalance required for reciprocating parts.

The advantages and economy of running locomotives over two or more divisions when topography of country and operating conditions permit, are as follows:

1st. Increased mileage. I have yet to learn of a single case where extending locomotive runs has not resulted in increased mileage over a period of time. However, increasing length of run 100 per cent does not necessarily mean an increase in locomotive mileage of 100 per cent, but it does usually range from about 30 per cent to approximately 100 per cent, depending on operating conditions, or, in other words, how the runs fit in with train schedules.

2nd. Reduction in number of locomotives required. An increase in locomotive mileage is equivalent to a corresponding increase of locomotives, and as shown by the extension of runs by the Southern Pacific Company between Sparks and Ogden, the same 15 locomotives made 68 per cent more mileage per month after they were run through, which enabled them to do the same work as 25 locomotives operating over the old runs.

3rd. Increased Railroad Capacity. The railroads of the country today are handling heavier traffic than at any time in their history. They are being hampered on all sides by legislative committees, which makes it very difficult to finance new facilities and equipment; hence the importance of getting the most out of what we have.

Reduction in work for locomotives at small outlaying terminals permits reducing the number of expensive tools required at such points, where they are used only a portion of the time and permits assembling them at main terminals where they can be utilized to greater advantage, thus reducing the investment in these facilities.

4th. Economy at Terminals. Locomotives running over two or more divisions do not require at the intermediate points the attention of wipers, hostlers, ash-pit and coal-dock men, machinists, boiler inspectors, etc. The cost of turning locomotive after it has made two or more divisions is very little if any more than if similar attention had been given at intermediate points, and repairs can be made in a more substantial and workmanlike manner as, there is ample time and facilities to take care of them.

5th. Saving in Fuel. During the year 1921 about one-fifth of all locomotive coal used, or 25,000,000 tons, was consumed when the locomotive was not doing useful work.

Waste of fuel account dumping coal fires, and rebuilding fires as well as fuel for keeping locomotives hot is saved, which amounts to a considerable sum. The Eastern road reports cost of displacement about $12 and that at the particular point account running through the dispatchments was reduced by 28 per day, thus making a saving of $336 per day, or approximately $10,000 per month from this cause alone. The amount of fuel required to keep locomotives hot and prevent freezing at outlaying points, in cold climates, is a big item. The amount of coal lost in dumping and rebuilding fires is estimated at from 1 to 2 tons per locomotive dispatched, and with coal at from $3.50 to $5 per ton represents an item of importance in the reduction of expenses.

On lines using oil this saving is not experienced, but they do enjoy the saving on account of not having to keep engines hot at intermediate points. At one point alone, in cold climate, this has been estimated at $15,000 per annum.

Maintenance Costs With Long Runs

Now, let us consider the possible disadvantages, increased cost of maintenance and increase in engine failures. Maintenance is also a factor to be considered in connection with long locomotive runs, since an increase in the daily mileage of motive power and a reduction in the time held at roundhouses would presumably affect the condition of locomotives. For this reason particular inquiry has been made in regard to the average mileage between shoppings of locomotives operated on long runs and it appears where records are available the mileage made by these locomotives between shoppings is as high, if not higher, than when run over short runs.

It would appear reasonable that we should get as much if not more mileage out of a locomotive if run off in, say, 2 years' time than in three or four, as we know time and the elements collect their toll whether locomotive is in operation or not. Also, it is a question if the cooling down and firing up strains in a locomotive do not do more damage than fair service.

In the case cited of the long run on the Southern Pacific between Sparks, Nevada, and Ogden, since the locomotives went into service they ran off 47,691 miles in ordinary service at the rate of 5,299 miles per month, and up to December 31, 1923, had run off 213,380 miles in long runs, averaging 8,891 miles per month. This makes an average total mileage of 261,000 miles up to January 1 of this year, and will probably average about 300,000 miles before locomotives go into shops for general repairs, which is certainly not discouraging for long runs.

The question of possible increase in engine failures has been watched by those interested in long runs and it appears that engine failures apparently are not affected by the mileage which the locomotive makes during its individual run. Analysis of engine failures shows that the majority of the failures take place on the first division and that the mileage of the individual runs has little or no effect upon the number of engine failures experienced.

Special attention and care are necessary in making long runs successful. Much depends on the care exercised on the part of the engine crew, inspectors and shop forces. A locomotive offered for service must be in good condition, which means that all details requiring attention have received that attention and where repairs are made that they be of a permanent nature, and not of a temporary nature. This latter practice frequently occurs on ordinary runs, in order to get locomotives back to main terminal. Then, oftentimes, on arrival at main terminal the men are especially busy, or think they are, and "Let her go for another trip."

Engineers should report on blanks provided for that purpose all parts that are not working properly or that in their judgment require attention. This is especially necessary where crews are changed, so the proper attention can be given on arrival of locomotive at terminal.

Lubrication is especially important and engineer should give particular attention to this; also, shop forces should see that all parts will lubricate properly.

On coal burning roads it is important that fireman keep his fire in proper condition up to the time he is relieved, so that fireman taking the locomotive will not be put to undue difficulty.

By building up long runs gradually and supervising closely, these items of lubrication, work reports and fire conditions may be eliminated and no more trouble experienced with them than on shorter runs.

Conclusions

After all is said and done, the consideration of prime importance is, not so much the attainment of the longest possible locomotive runs, as it is to obtain the greatest mileage per unit of time per locomotive owned, and the smallest fuel consumption, and the least expenditure for repairs and enginehouse attention. This can best be done by designing equipment to fit the special service requirements, providing boilers of ample capacity, and applying standard devices that will increase the efficiency and reduce fuel consumption. Particular attention should be given to the design of various details, using high quality material in such parts where reduction of weight will minimize the stresses set up in machinery and in track and roadbed. Select the softest natural feed waters available, and chemically treat those that contain objectional impurities, reducing these impurities to a minimum, and provide hot water boiler washing facilities at terminals to reduce cooling down strains in boiler and save fuel.

A New 10-Ton Crawling Tractor Crane

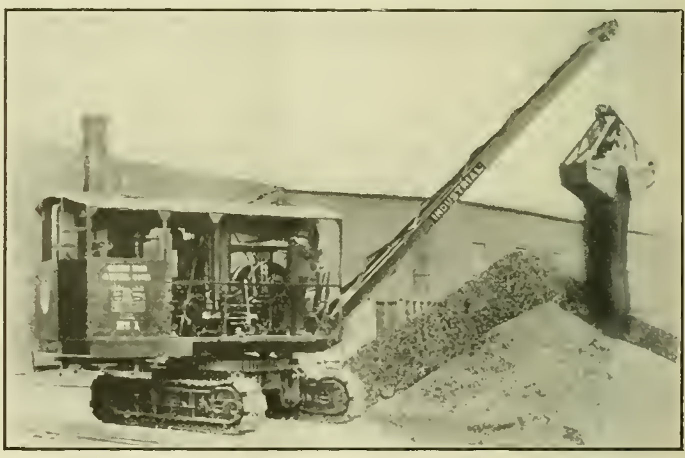
The Industrial Works of Bay City, Michigan, which recently designed and built several 200-ton locomotive cranes which were the largest in the world, now offer a new type at the other end of the scale. This is a 10-ton crawling tractor crane embodying many new engineering features and known as type "D."

One of the most important features is the independent control of the traveling, slewing and hoisting motions. These motions may be utilized in a variety of combinations which are said to result in a greatly increased speed and efficiency of operation. For instance, the hoisting and slewing motions may be combined in bucket work for operation at high speed and when traveling, the boom may be swung in any direction to clear obstructions. Slewing in either direction is accomplished without reversing the engine by means of a double friction clutch and a train of bevel and spur gears. A slewing brake holds the boom securely with a suspended load in any position. When operating on uneven ground, this brake eliminates any possibility of sudden rotation with its usual disastrous results. The vertical slewing shaft is located accessibly at the front of the crane close to the base of the loom, and since the power is transmitted at this point, there is no great slewing stress carried through the revolving frame.

The entire upper works rest on a rotating steel base, which insures rigidity and perfect alignment. This base rotates on four conical steel rollers which are easily accessible and which may be taken out without removing any of the parts or jacking up the crane. Heavy steel side frames which carry the shaft bearings are bolted to this rotating bed. These bearings are arranged on the outside of the frames so that any shaft may be easily removed without displacement of other parts. All running bearings are provided with replaceable bronze bushings. Wearing surfaces of all thrust bearings are separated by bronze washers and bronze collars are placed behind each bevel gear. All gears in the upper works are of cut steel. All oil pipes lead to the operator's platform and the lubrication is accomplished by a pressure system. Clutches controlling the various motions are of a new friction type which are said to engage smoothly and without shock.

Tractor shoes are close fitting, smooth surface steel and they operate over adjustable idle sprocket bearings which take up the slack in the tractor belt. Five large size rollers of 25 in. diameter on each side decrease traveling friction and keep the bearings high up out of the dirt. The steel bed plate mounted on the car body is cast integral steel with a circular roller path and external slewing rack. A steel hollow center post is pressed under heavy pressure into this base plate, taking all unbalanced stresses and forming a center of rotation for the super-structure.

The crane has two traveling speeds and reversal of direction is accomplished by reversing the engine. Steering while propelling is accurately accomplished from the operator's platform through friction clutches and brakes controlling each tractor belt. Either belt may drive, coast or be held by brake in any degree to negotiate as sharp or wide a turn as desired. This propelling and steering mechanism is one of the exclusive features of this type "D" crane. It enables the operator to propel and steer the crane independently of all other motions with the boom in any direction. It is especially powerful, enabling the crane to travel up steep grades and over rough ground. Propelling up an incline skidway onto a flat car for transportation is very easily done. Other exclusive features are the automatic double hoisting drums which provide automatic control of the bucket during operation. Both



Ten-Ton Crawling Tractor Crane

drums provide enough rope pull as required for dragline and hoisting purposes. The feature of hoisting the bucket open on the auxiliary drum greatly increases the output of the crane and makes operation much simpler. A radius varying appliance consisting of bronze worm, worm wheel and drum, and controlled by friction clutches and semi-automatic brake, raises or lowers the boom when loaded to its maximum capacity. Levers actuating all motions are conveniently placed in two rows in front and alongside of the operator's platform, which is located on the right hand side with a full view of the work being done.

The new Industrial is built for either steam, electric or gasoline power. The steam crane has two horizontal, double acting cylinders 6 in. in diameter by 8 in. stroke of piston. The engine is equipped with a simple radial type reversing gear, by means of which loads may be lowered and the hoisting line payed out by power. The cylinders and crosshead guides are cast in one piece and bored at the same setting, thus insuring accurate and permanent alignment. The gasoline crane is equipped with either the "Buda," Climax, Wellman-Seaver-Morgan or Automatic semi-Diesel engine.

The crane is extremely versatile, operating with clamshell or dragline bucket, electro-magnet, hook and block or grapple.

Some Notes on the Early History of the Air Brake and Air Signal

The Co-operation of the Officials of the Pennsylvania Railroad in Their Development

By GEORGE L. FOWLER

Chief among the details that have done much to insure safety in the operation of railway trains as well as to make high speeds a possibility is the air brake.

The first practical demonstration of the use of the air brake was made on the Panhandle Railway in 1868, and so successful was this work that an application of an equipment was made to a train of six cars on the Pennsylvania Railroad, and in September 1869, this train was placed at the disposal of the American Railway Master Mechanics' Association, representing numerous railways, which association was then in session at Pittsburgh. The train was run to Altoona and the air brakes were used exclusively for controlling the speed of the train on the eastern slope of the Alleghenies. This was done on the recommendation of Robert Pitcairn, who was then the general superintendent of the Pennsylvania Railroad. There were of course some difficulties in this early application. At first the pump failed to work, but the difficulty was soon remedied and the train, alluded to, was fitted with the brake at Pittsburgh; much of the work having been done in the Pittsburgh shops of the Pennsylvania Railroad. This train made an exhibition run to Altoona and afterwards to Chicago returning by way of Indianapolis.

Early in the following years 1870 the Pennsylvania had entered upon the equipment of its cars with the air brake as is evidenced by the first payment made to the Westinghouse Air Brake Company in April. This was while Isaac Dripps was superintendent of motive power, and the work of installation continued slowly under the brief regime of his successor.

It was, then, through the Pennsylvania Railroad that Mr. Westinghouse obtained the first recognition, assistance and encouragement that started the development of the air brake. Matters were progressing in this way until 1873 when Mr. Frank Thomson was appointed superintendent of motive power. Mr. Thomson was an enthusiastic believer in the brake and started a campaign of rapid introduction.

Up to this time, 1873, the brake was in its straight air form. That is to say, compressed air was admitted direct from the reservoir upon the engine to the brake cylinders beneath the cars for the application of the brakes. With this design of apparatus the brakes became useless if an accident occurred to the connections and it was soon supplemented by the automatic brake. This brake is so arranged that it will be applied in case of a rupture of the connecting pipes, and can also be applied from any car in the train by opening a valve and allowing the air in the train pipe to escape into the atmosphere. It involved some extra complications of apparatus beyond that required by the straight air brake, including an air reservoir beneath each car and a triple valve to admit the air to and release it from the brake cylinder where the pressure was applied directly to the mechanism by which it was transferred to the brakeshoes and wheels.

As in the case of all new devices, the triple valve was at first quite complicated and bulky and not equal to the requirements that were to be put upon it. In short, the crude idea had been proven to be theoretically sound but it remained to develop the mechanism into one that would be reliable under all of the varied exigencies of service. To do this required time, patience and facilities. Mr. Westinghouse could furnish the first two, but the latter involving, as it did, the use of trains and cars in actual service, could only be supplied by a railroad company whose officers had such faith in the device as not to be discouraged by apparent failures.

Mr. Thomson, as previously stated, had believed in the air brake and during his regime the Pennsylvania Railroad had permitted Mr. Westinghouse to carry on his experiments with a free hand. A special train, known as the Wall local, running from Pittsburgh to Wall had been assigned for this experimental work and with this Mr. Westinghouse was free to do as he pleased.

Among the first of the improvements that was made was in 1875 to dispense with the use of the second or return train pipe. Then followed the gradual introduction of the automatic brake, the straight air being used in the meantime for all train operation, until, in 1879, a sufficient number of cars had been equipped to warrant the change to automatic operation in train service, which was done, and since that time the operation of train brakes by straight air has been a thing of the past.

Meanwhile during this early period of introduction and transition from straight air to automatic operation the pressure upon the brakeshoes by which they had been applied to the wheels was very low, being only about forty per cent of the weight of the wheel resting on the rail. Meanwhile in 1878, the famous Westinghouse-Galton experiments with brakes had been executed in England. These experiments showed conclusively that a higher brakeshoe pressure could be used when the train was moving rapidly than when it was moving slowly.

It seemed that the whole possible efficiency of the air brake was not being obtained, so it was decided to increase the brakeshoe pressure and to raise it to sixty per cent of the weight on the wheels. The change was of great value in increasing the efficiency of the brake and thus decreasing the distance required to stop a train. The wheels were not slid and flattened, and the pressure was soon afterwards increased to seventy per cnt of the weight on the wheels of an empty car, where it has ever since remained for freight service.

Hardly had the automatic air brake been established for train operation in 1874 when an aggitation was begun for the application of some sort of a power brake for freight cars. During the early eighties neither the general public nor the average railway official considered that it would be possible to use the air brake for this service because of the expense involved in the installation. But the aggitation went on and the general belief prevailed that some sort of a buffer brake to be actuated by the compression of the draft springs would be the best means of accomplishing this end. When the Master Car Builders' Association decided to conduct a series of tests with power brakes on freight trains of as much as fifty cars in length at Burlington, Iowa, on the line of the Chicago, Burlington & Quincy Railroad in 1886, no trains of so great a length had been operated with power brakes of any kind as the means of control. In order that the matter might be studied somewhat in advance of the work to be done at Burlington, the Westinghouse Air Brake Company equipped a train of fifty cars with the automatic brake at Altoona. This was the first train of that length which had ever been brought together. The first run was made eastward from Altoona to Huntington, and though they got a good many bumps, it was successful. They then went west to Conemaugh in order to test the brake on the long grade down the eastern slope of the Alleghenies from Galitzin into Altoona.

The engineer, Daly, was chosen for his skill and was a first class passenger man. In making his first application he released air from the train pipe until he felt the brakes take hold and then moved his brake handle to lap just as he would have done on a passenger train. But as the air surged forward from the rear of the train, it released the brakes at the front; to remedy which a second and third reduction of the air pressure in the train pipe was necessary. Mr. George Westinghouse, who was sitting back of the engineer, saw at once, that such a method of operation would be intolerable and asked to be allowed to manipulate the brake. For the next application he opened the valve, which was a three-way cock, and allowed air to escape, and then slowly closed it, gradually throttling the escape of the air, but still allowing some to escape until the train pipe pressure was equalized, and thus prevented the action of the surging of the air from the rear and the release of the brakes.

Realizing that it would be too much to expect that the average engineer should handle the brakes as he had done, Mr. Westinghouse at once designed the engineer's equalizing and exhaust valve, by which the difficulty was guarded against. So from this one trial on the Pennsylvania Railroad a great improvement in the air brake mechanism was evolved.

The details of these items of air brake development are told in order to give some idea of the atmosphere in which the work of that development was conducted, and the sympathy felt for it by the officers of the road.

This was done but a short time prior to the brake tests that were made at Burlington, Iowa in 1886 and 1887. Here in 1886 it was demonstrated beyond any doubt, that the automatic air brake, as it then existed, was quite unsuited for use on long freight trains. So immediately after these first tests of 1886, Mr. Westinghouse perfected and brought out his quick action brake, wherewith the time required to apply the brakes to the rear of a long train, was greatly reduced and the apparatus was thus made available for such work.

At the conclusion of the Burlington tests in May, 1887, the Westinghouse Air Brake Company sent its train over the country making exhibition tests on various railways concluding with one on the Pennsylvania Railroad near Philadelphia. These were so successful that as soon as they were completed the Pennsylvania made a contract for the equipment of a large number of freight cars with the new quick action brake. It was, therefore, the leader in that movement which later culminated in an order of the Interstate Commerce Commission requiring all freight cars used in interstate traffic to be fitted with air or power brakes.

Later, in 1902, when the first high speed trains were put in service between New York and Chicago, the Westinghouse Air Brake Company brought out the high speed brake, by which an excessive brakeshoe pressure is applied at first, and which is gradually reduced as the speed is decreased so as to harmonize with the coefficient of friction of the shoes. The first application was made upon one of the trains of the New York Central, but the Pennsylvania was quick to take up the idea and the second train to be equipped was its Congressional Limited running between Jersey City and Washington, which was done under the authorization of Mr. Theo. N. Ely. Its advantages were so quickly apparent on this train that its use was rapidly extended and it was soon adopted as standard; the Pennsylvania being the first railroad in the world to take that action.

During the period of Mr. Ely's administration, the application of brakes to driving wheels of locomotives was commenced and made standard upon the Pennsylvania system, being used with every stop.

It was during the period of the development of the air brake, about 1882, that Mr. Westinghouse devised the air signal to take the place of the old bell cord as a means of signaling from the train to the locomotive.

As first designed, the operating wave was sent through the main train line. This worked all right when the air in the main train pipe was quiescent. But, when the brakes were being applied or released, the signal was either rendered inoperative or would give false indications. It was so unreliable as to constitute a positive menace to safety, were it to be used.

As it is frequently necessary to signal from cars to the locomotive under these circumstances, this defect was of so serious a nature as to bar any possibility of the air signal being applied in service. Mr. Westinghouse then designed the separate signal pipe and set up in connection with the brake rack in the Altoona shops, more from an interest in the matter than from any expectation of a possible commercial development. For neither he nor any one associated with him thought, for a moment, that any railroad would think of substituting an expensive extra line of pipe throughout the whole length of the train for the cheap and fairly efficient bell cord which was the, then, only method of signaling from the train to the engineer. But there were objections to the bell cord and the device worked so well on the rack that Mr. Westinghouse was authorized to equip a train with it. This was done, and, so satisfactory was its operation that its use was gradually extended until it has finally entirely superseded the use of the old time bell cord on all of the roads of the country.

Freight Train Mile Costs Lower This Year

A special report of the Interstate Commerce Commission showing freight and passenger train service costs, explains the reductions, accomplished this year in the costs of producing service per freight train mile.

Locomotive repairs in the first five months of this year per freight train mile amounted to approximately 44½ cents compared with 51½ cents in the same period a year ago. Fuel for locomotives this year cost a little more than 47 cents per freight train mile compared with approximately 56 cents a year ago.

Engine house expenses in the first five months of this year amounted to 9½ cents a mile compared with 9.8 cents a year ago. The cost of enginemen amounted to 24.9 cents per freight train mile compared with 27.2 cents a year ago, while the cost of trainmen amounted to approximately 29 cents compared with 31 cents a year ago.

Other locomotive and train supplies amounted to 10½ cents in the first five months of this year compared with only 9.7 cents a year ago. The total of the accounts selected in the Commission's report shows reduced costs per freight train mile this year of from approximately $1.85 to $1.66.

The millions of dollars saved will be used for improvements and extension of service and to take care in a measure of the increased cost of other phases of operation.

Snap Shots By the Wanderer

No one who has watched the progress to and development of the present day parlor and sleeping car can accuse the Pullman Company of neglect to attempt to meet its obligations to the public. Improvement after improvement has been added of its own initiative and without any outside pressure being brought to bear. Aside from the improvement in the riding qualities of the cars, there have been the innumerable little things, contributing to comfort. Some of these little things are the substitution of a cock for a pump at the wash basins, allowing the water to flow under an air pressure; the change from an open to a water-sealed hopper in the toilets; the introduction of the berth lights; the split curtains by which the upper and lower berths are separated; the coat hanger and a mass of other little things that we did not ask for but which we now consider indispensable for our conduct.

Nor is it generally even known that elaborate investigations have been made as to the ventilation and the condition of the air behind the curtains in the berths. And many a passenger has slept away the night unconscious of the extracting tube that has been thrust through the parting of his curtains, to withdraw samples in order to determine the character of the air that he was breathing.

The company has even gone so far as to attempt to educate the irresponsible public to a greater consideration for and courtesy toward each other. An attempt which, up to the present time, cannot be said to have met with what could be called a notable success. Probably because the methods adopted have been too characteristic of a gentleman without a full realization that that was not the sort of an animal that it has to deal with.

As for their porters, they are usually courteous, if sometimes a little too persistent in their attentions in view of extracting the possible though reluctant tip. The tip being the chief end of a porter's life, he is frequently more eager to "dust you off" than he is to make his passengers comfortable by putting up the berths before an early morning arrival at a terminal; with the result that many are sitting around in berths that are down, rather disgruntled and always grumbling, while the porter is assiduously "dusting off" the mildly submissive victims. I am aware that there are rules forbidding this practice. But the making of a rule or law and its enforcement are often two quite different things, as possibly Mr. Volstead may realize.

The porter's indifference to the temperature of his car while standing at stations in cold weather is a source of much grumbling. The door is always left wide open during the whole of a stop, unless it is closed by some nearby and indignant passenger, and many are the colds contracted thereby. It does seem as though something could be done to mitigate this neglect. But as far as I can ascertain the officials are indifferent and pay no attention to the complaints that are made about it.

Then, the parcel rack in the parlor cars is wholly inadequate to meet requirements. It serves well for coats and wraps, but the passengers' satchels are still kept on the floor, quite in the way, and a nuisance generally. I believe I have heretofore called attention to the fact that the long, continuous, wide rack has not yet, after an existence of fifty years, come into general use in the day coach. So, perhaps, it is too soon to expect such an innovation to appear and take root in the conservative regions of the parlor car. But, humanity can live in the hope that some future generation will come into the enjoyment of this comfort and convenience.

And before I stop I want to make one more suggestion. It would add greatly to the pleasure of those travelers who travel for pleasure, if there were to be some coordination of the spacing of the windows and the seats in the parlor cars. As it is, about every alternate seat is opposite a wide part that makes looking out a difficult strain and the view less than unsatisfactory. I am quite well aware that a window for and at every seat would detract from the external appearance of the car, but it would add considerably to the internal comfort.

I am quite well aware that the average passenger is quite oblivious to the outside beauties through which he may be passing. It moots little to him whether the window view discloses the flat lands of the West, the glories of the Rockies or the rich beauties of the flowering fruit trees of Virginia in early May. But once in a while there is an abnormal human, that likes to look at these things and it seems to me that he is worth catering to.

And after all isn't it what the passenger agent advertises in order to attract the prospective traveler? Of course, we all know, that he does it with his tongue in his cheek, he knowing full well that his prospective traveler won't care a hang about it as soon as he ceases to be "prospective" and becomes the real thing. But, then, be this as it may, he ought at least to deliver the goods which he advertises and the Pullman Company ought to aid and abet him and not make it impossible to half of its parlor car riders.

That isn't intended as a tirade but simply as a plea "for something better than we have known." For as I write my memory drifts back to the days when parlor cars were unknown; when even the monitor roof was yet to come, and when the link-and-pin served all the purposes of a car connection. When there was a plank bridging the gap between cars, the crossing whereof was attended with risks that the Bureau of Safety would not tolerate today.

I remember the smoking cars. The seats arranged along the sides, hard, cushionless and cold. The four small high windows with their four panes of glass. Windows that were never opened and leaving all ventilation to the occasional opening of the door. And this scarcely mitigating the thick atmosphere of tobacco smoke, through which at night we could see the dim light of a smoking oil lamp; smoking to be in harmony with the rows of dim figures ranged along the walls. No possibility of reading, seeing or hardly breathing, for to the atmosphere of smoke was added the odors of a spittle-covered floor, and the dirty boxes filled with sawdust that served as spittoons, the dimly-seen target for the more or less expert expectorators. Hygiene was unknown and the board of health of the future was yet to clean the car floors and make of this common practice a misdemeanor. Then add, in winter, the wood-burning stove, with its frequent back draughts and outpouring of smoke, and perhaps your vivid imagination can pencil a picture of our old recollections.

Well, when such memories drift before me, I wonder what the exacting man of today would do if he were thrown into the lap of these luxuries of his forefather's. And, after all, when you come to think on these things the modern coach and parlor car are not such very bad things after all, and perhaps it will be well to be patient for a while longer for 'tis said that "all good things come to him who waits," and perhaps the closed door and the long, wide rack may be found among them.

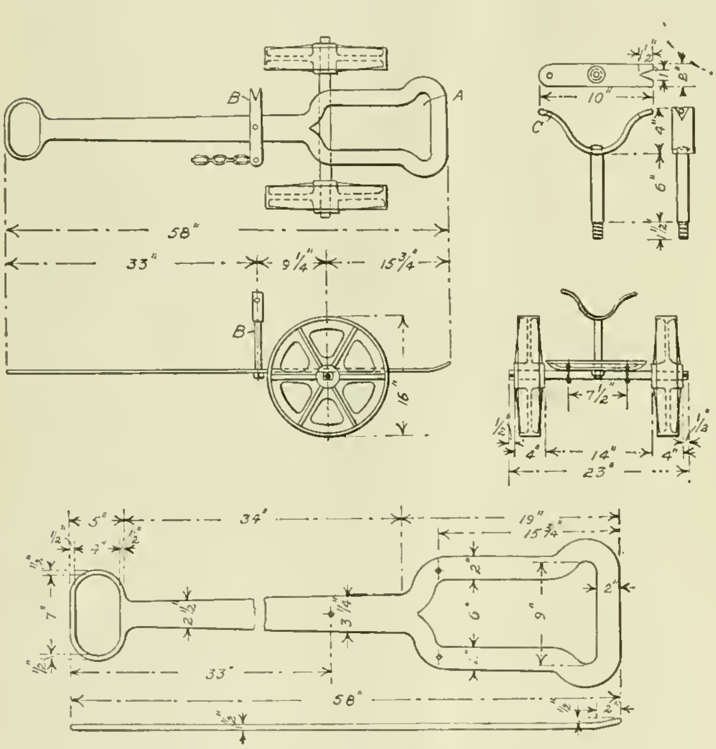
Shop Kinks

Some Useful Devices in Use on the Erie Railroad

Trucks for Handling Jacks

The jack truck is a common and every day device in most railroad shops, but many of them are cumbersome and not well adapted to the work that they have to do. On the Erie there are two types of jack trucks. One is intended for use about the yards and the other for use in the shops. They are similar in general design but differ in the details of their construction, which are adapted to their several purposes.

The yard truck is mounted on wheels 16 in. in diameter having a width of tread of 4 in. The axle is 1½ in. square, with journals 1 in. in diameter turned at the ends and the wheels are held in place by ¼ in. cotter pins. The handle is of the shape and dimensions shown in the detail. The two legs of the handle are riveted to the axle by ⅜ in. rivets and, at the end they are bent outwardly to form a pocket *A* for the reception of the base of the jack. A holder *B* is attached to the handle 9½ in. in front of the center of the axle. The upright is 1 in. square and 6 in. long between shoulders and is turned for a ⅞ in. thread at one end where it is fastened to the handle by a nut beneath the same. The upper end is turned smooth and is slipped through a hole in the trough-shaped holder *C* and riveted over. The holder *C* is of 2 in. by ⅜ in. flat steel with a ⅝ in. hole at one end to take the holding chain, and a V-notch at the other to catch the link of that chain and hold it when it is thrown over the jack after the latter is in place.

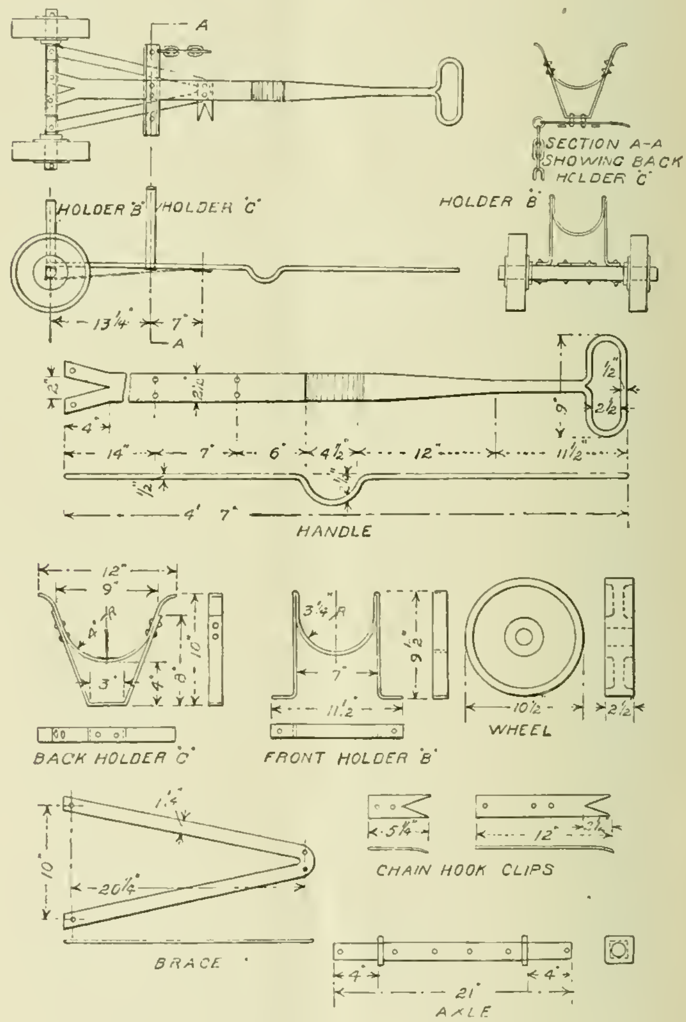


Details of Truck for Handling Jacks About Yard

The truck for use about the shops is carried on wheels 10½ in. in diameter, with a 2½ in. tread mounted on an axle 1½ in. square and 21 in. long. At the inner end of the 1⅜ in. diameter journals a ½ in. collar is welded on, this collar being square in end elevation to conform to the section of the axle. Washers are used on each side of each wheel.

The handle instead of being made with a pocket to receive the base of the jack and projecting beyond the axle, is simply slightly forked at the axle end and is riveted to the same and then braced by two diagonal braces.

There are two holders for the jack. The holder *B* is made of 1¼ in. by ¼ in. flat steel of the shape shown and is rivetted to the axle and forms merely a bed on which the jack rests. The holder *C* is of the same size of metal and is riveted to the handle at a distance of 13¼ in. from the center of the axle. It is built up of two pieces rivetted together and forms a second bed piece similar to that of holder *B* and at the same height above the handle. The radii of the two holders *B* and C are 3¼ in. and 4 in., respectively. Then, as the jack lies on the holders there is an offset of 2¼ in. in the handle to afford clearance for the head.

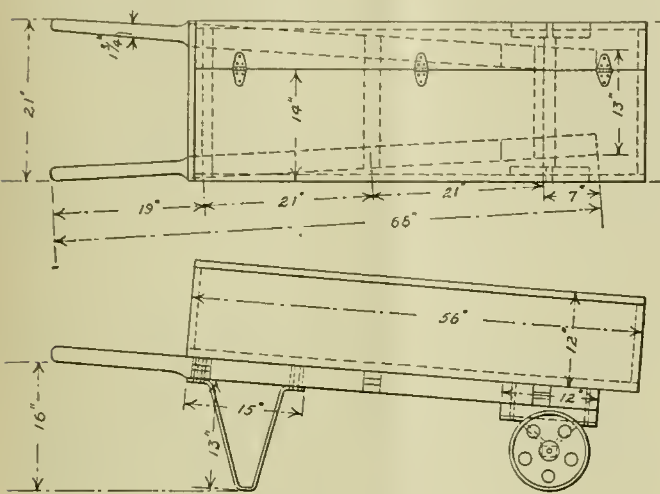


Truck for Handling Jacks About Shops

There are two chain clips for holding the jack in place, each of 2 in. by ¼ in. metal and each having a binding chain attached to one end and a fork at the other to catch the link of the chain. The longer of the two is riveted to the handle beneath the holder *C* and the other 7 in. back of the same. The chains are 6 ft. long and of the size ordinarily used for the fire doors on locomotives.

Portable Tool Box for the Round House

Closely allied to the trucks for handling jacks is the portable tool box for the roundhouse, which was designed and built at the Port Jervis shop. It is simply an ordinary freight handler's truck in which a tool box 56 in. long, 12 in. high and 20 in. wide is mounted. The wheels are 10 in. in diameter with a 2 in. width of tread, and the ends of the handles extend 5 ft. 1 in. back of the center



Portable Tool Box for Round House

of the axle. There is a lid at the top of the box 14 in. wide and held by three strap hinges; the box and lid being made of boards 1 in. thick.

The handles, which also form the underframe of the truck are 2¾ in. square and the legs are of 1¼ in. by 2 in. iron. It is a cheap, substantial and handy device, the only machine work required in its making being the turning of the journals on the square 1¼ in. by 1¼ in. axle, drilling it for cotters and bolts for the frame, drilling the legs and the ½ in. by 2 in. iron step for the axle.

Pneumatic Pipe Bender

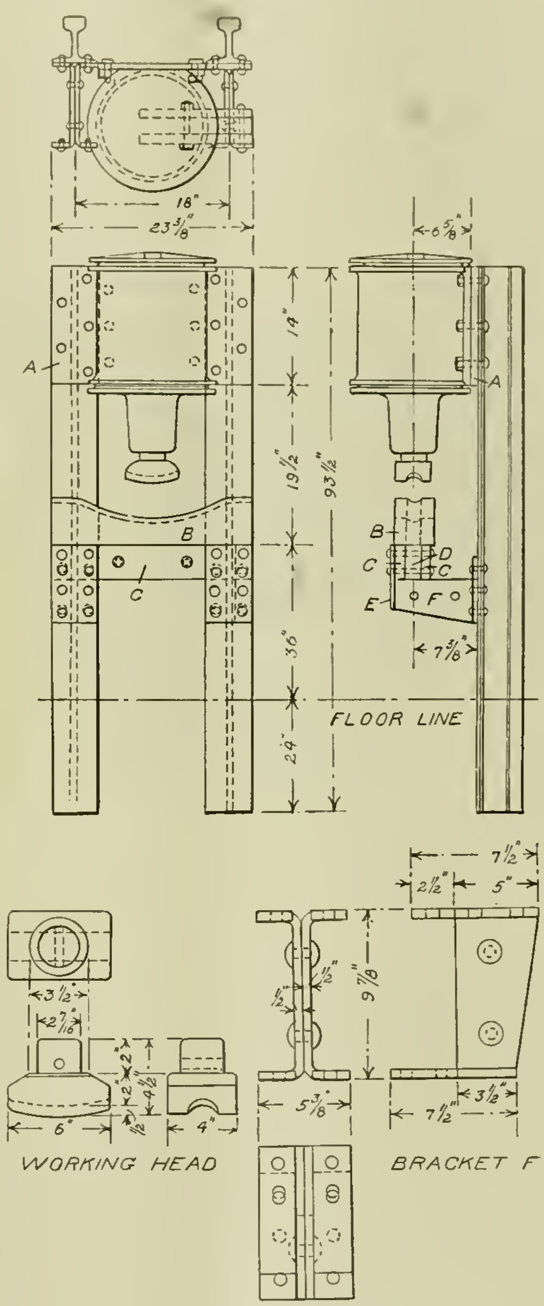
This pipe bender consists of an inverted pneumatic cylinder mounted upon the flanges of two rails each 7 ft. 11½ in. long, a length of 2 ft. of the lower end of which is embedded in a concrete foundation, the top of which is on a level with the floor.

The rails used are scrap rails weighing 90 lbs. to the yard. All holes in the rails, plates, angles and cylinder flanges are 13/16 in. in diameter for ¾ in. bolts and rivets. The rails are set 18 in. from center to center of their webs, and 23⅝ in. from out to out of their flanges. Riveted to the upper end there is a plate A ¾ in. thick and 14 in. deep to which the cylinder is bolted by six ¾ in. bolts. The cylinder has an internal diameter of 12 in. with a ⅝ in. thickness of shell.

The piston is single-acting and is pushed back to its upper position by a retracting spring set in the base of the lower cylinder head.

A working head is attached to the lower end of the piston rod and is fastened by a 9/16 in. diameter pin. The lower part of the head is fitted with a groove of 1 in. radius and ½ in. deep that is curved on a radius 4¾ in.

The anvil is made of oak and is cut with a groove similar to that in the head, but with a radius along the length of the groove of 16 in. This anvil *B* has a length (23⅝ in.) equal to the distance from out to out of the flanges of the rails, and it is 4½ in. thick. Projecting from the underside of the main body of the anvil is a tenon *D* by which the anvil is held in place. It is set in between two ¾ in. by 4 in. plates *C* that are rivetted to the upturned flange *E* of the bracket *F* with a separator between them. There are two of these brackets *F*, one of which is rivetted to the flange of each of the rails. The plates *C*, then rest upon the brackets and the anvil upon the plates.



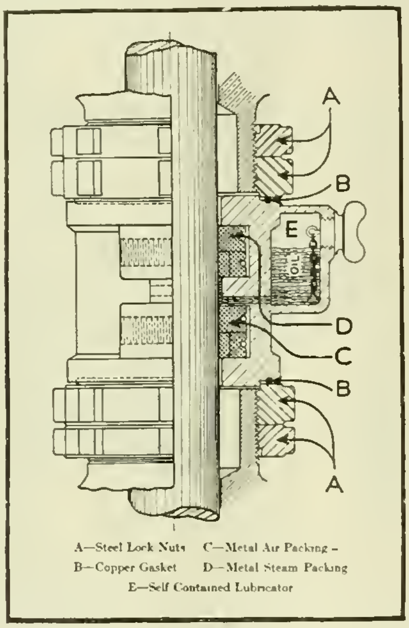
Details of Pneumatic Pipe Bender

Air is admitted to the upper end of the cylinder by means of a two-way cock, by which it is also exhausted.

All Metal Packing for Locomotive Air Pumps

On account of the constantly increasing demand for compressed air service on both passenger and freight locomotives the development of the air pump and its accessories has recently been given special attention. There has always been a need for an air pump packing that could be applied economically and would operate over a long period of time without replacement and close watching. Within the last month there has been introduced to the trade a new all metal packing for use on locomotive air pumps. This particular packing can be applied to any type of pump without change in its construction.

Heretofore it has been necessary in the application of metal packing on air pumps, to provide an oil swab and swab container with pipe connection to a separate lubricating cup. Due to engine vibration the oil cup had to be bracketed to the body of the pump to prevent it from working loose. Also at each end of the swab container, metal rings of different construction are placed in beveled vibrating cups. These rings are forced through the rod by a large spring encircling the rod and by contact with the bevel on the vibrating cup. The features and construction of the new all metal packing are quite different in comparison with other types and a much longer life of usefulness is claimed for it by The Garlock Packing Company of Palmyra, New York, who are responsible for its development and introduction. Oil cups, oil swabs and vibrating cups are entirely eliminated in its construction. Lubricant is fed to the rod and packing rings from an oil reservoir which is cast as part of the split case surrounding the rings and any excess of oil fed to the packing rings will not be wasted for the reason it gravitates into the cylinders of the pump. The packing rings, two in number are of a new design constructed with mechanical accuracy from four segments which break joints in the center of the rod bearing surface. Each of the four segments travel or wear toward the center of the rod over a flat smooth surface and under an even circular spring pressure. Ordinarily, one ring is sufficient to hold either the steam or air pressure on locomotive air pumps. The construction of the new packing is such that the air ring will aid the steam ring in holding steam and the steam ring will aid the air ring in holding air. The combination of the two rings working in unison will positively prevent the leakage of either steam or air and the wide bearing surface each ring has on the rod and the grooves of the case insures long life.



All Metal Packing for Locomotive Air Pumps

The metal case surrounding the rings is split or made up in two separate halves and held together with screws sufficiently large enough to prevent any leakage between the halves. It is also designed to snugly hold one ring in each of its two separate grooves.

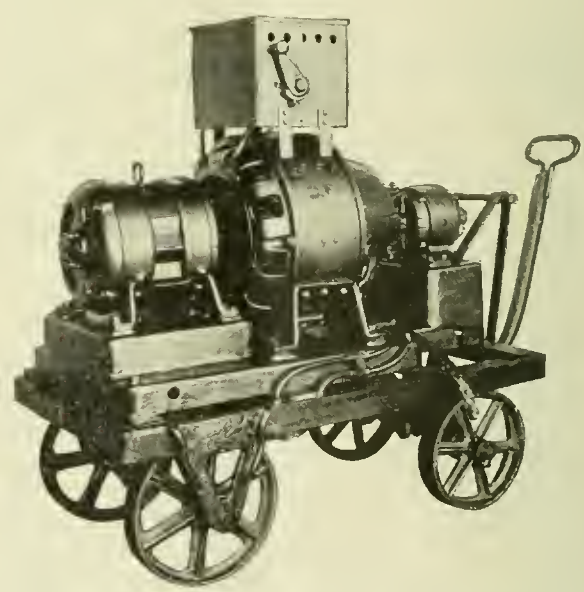
The means of holding the metal packing in position is not the least of its new features. On each end of the case is turned a short projection which is used as a guide in centering the case true with the rod and the stuffing box. This centering is accomplished by entering this projection into the recess turned into the bore of the screw lock nut fitted on to the threads on the outside diameter of the stuffing box. As these lock nuts are tightened, they are brought into contact with a copper gasket embedded in each end of the case and when properly seated with a spanner wrench, supplied by the manufacturer, they perform a double duty of rigidly holding the packing in absolute alignment with the rod and forming a metal gasket seal as well.

The split case entirely encloses the rod making it impossible for dust or grit to reach the rod or packing. It also gives accessibility for the quick application of renewal rings.

New Westinghouse Single-Operated, 200-Ampere Arc Welding Equipment

The Westinghouse Electric and Manufacturing Company has recently designed a compact, entirely self-contained, single-operated 200 ampere arc welding apparatus which is available in either the stationary or portable form. This equipment is described in Descriptive Leaflet L-1719.

The generator will deliver 300 amperes on intermittent work. Any welding current from 60 to 300 amperes may be obtained by operating the rheostat handle which is conveniently located outside the control cabinet which is mounted on top of the generator. The 61 rheostat resistance steps enable the operator to obtain close current control if desired.



Portable Single-Operated Arc Welding Apparatus

If an extremely high current is desired, the generators of several machines may be operated in parallel. The generator is designed to inherently stabilize the arc, thereby overcoming instantaneously any resistance fluctuations in the arc circuit, and, at the same time, eliminating the necessity for relays, solenoid controlled resistors, etc. Because of the special design of the generator, the operator can readily strike and maintain the arc, obtaining the necessary penetration and fusion for good welding.

Any of the commercial sizes of metallic electrodes, from 1/16 in. to ¼ in. in diameter may be used.

The generator and driving motor are mounted on a common shaft to which the exciter is coupled by means of a special flexible coupling. Ball bearings are used throughout to eliminate the leakage of oil when operated on inclined positions.

The driving motor is of standard Westinghouse construction and may be either a D.C. type SK motor or an A. C. type CS squirrel cage motor, depending upon the character of the supply service. Alternating current driving motors may be used on 220 and 440 volt supply circuits by simply rearranging the lead connections.

Alternating current motors are started by connecting them directly to the line through a safety switch. Direct current motors are started by means of a D starting rheostat. In both cases, all the operating mechanism except the handle is within the control cabinet, eliminating the danger of contact with live parts.

An ammeter and voltmeter—if desired—are mounted on the cabinet where they are readily observed by the operator as he adjusts the rheostat for current control.

The rugged construction of the unit makes it particularly adapted to railway shops, and such places where welding equipment receives rough usage. The truck is sturdy and is equipped with roller bearing wheels so that it can easily be hauled by one man.

Landis Bolt Factory Threader

The Landis Machine Company, Inc., Waynesboro, Pa., have placed upon the market a new thread-cutting machine, which will be known as the Landis Bolt Factory

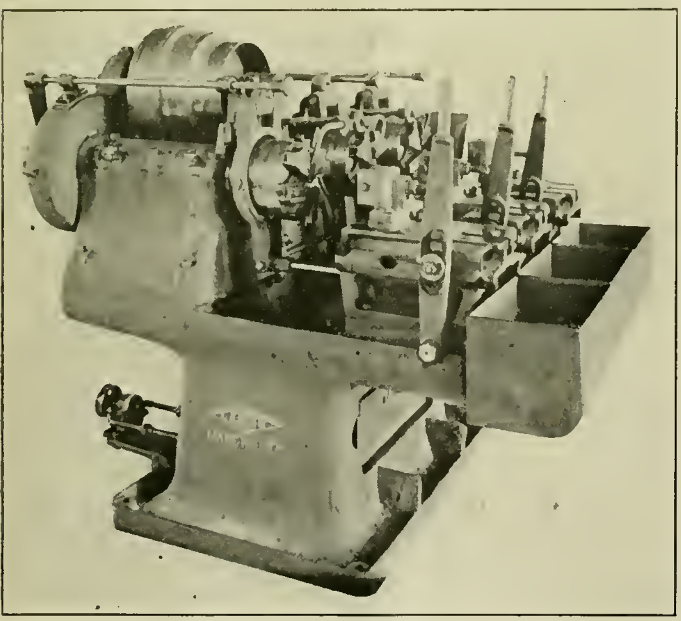


Fig. 1—Thread-Cutting Machine Carriages Equipped with Bolt Holders

Threader. This machine is designed and built for use in bolt factories, or in plants where a high production of bolts is required. This machine is sturdily constructed and will give a long life of hard service under high pressure conditions.

It is made in the 1-in. and 1½-in. sizes in the double and triple head types and in the 2-in. size in the double head type.

The spindles on the machine are located sufficiently close together to permit of an operator handling a three-head machine without shifting from one lever to another. The spindles are independent and are controlled by the clutches located at the rear. The clutches are operated by bars extending over the die heads. Any one head may be stopped without shutting down the entire machine.

The die head is opened and closed automatically. The tripping rods which connect the carriage and the yoke of the die heads for opening and closing them, are provided with stop collars. These collars are conveniently and quickly adjusted for various lengths of threads. All spindle gears have bronze bushings. The main bearings are capped and may be adjusted for any wear.

The carriage drive is in the center and comprises a rack and segment gear. These are thoroughly protected against

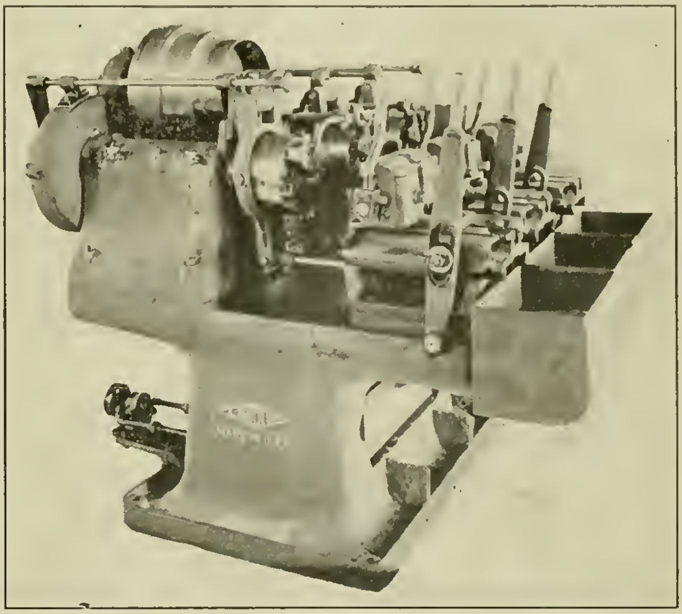


Fig. 2—Thread-Cutting Machine Carriages Equipped with Vise Jaws

dirt and chips. The levers operating the carriages are adjustable through a V-toothed clutch. This permits of a convenient position of the levers when cutting different lengths of thread. The levers may also be quickly changed from one side to the other side of the carriage for a right or left hand operator.

The carriages on the machines are furnished with either bolt holders or vise grips. The bolt holders or vise grips are easily taken off and applied quickly. Both have horizontal as well as vertical adjustment so that the work may be in proper alignment at all times. This is an exclusive feature on the Landis machine and insures good results throughout its entire life. The vice grips are lever operated, which facilitates production. The grips, which are separate from the sliding jaws, are hardened and are quickly changed without disturbing any adjustments. This is a pronounced advantage also. Fig. 1 shows the machine with the carriages equipped with bolt holders, while Fig. 2 shows the machine with the carriages equipped with vise jaws.

The machines are furnished with boxes for holding the bolts. These boxes are placed on the front of the machine and will not interfere in any manner with the operator. These boxes may be removed when threading long bolts.

A geared oil pump supplies an abundant flow of lubricant to the die head. All gearing and moving parts are protected so as to eliminate any danger of accident.

These machines employ the well known Landis die heads and long life Landis chaser.

Report on Power Brake Hearing

The Interstate Commerce Commission has issued its report on the Power Brake Hearings that were ordered in February 1922. The report was received too late to make an extended abstract in this issue, but, that will be done in September. The conclusions reached are stated in the concluding paragraphs and are as follows:

Improvements in the operation of power brakes for both passenger and freight trains are essential and must be effected.

Improvements in power-brake appliances can be made and increased safety in train operation can and must be obtained.

A power-brake system for passenger and freight trains should insure that only a service application of the train brakes will occur when a service reduction of brake-pipe pressure is made.

A power-brake system for passenger and freight trains should provide means whereby effective emergency brake-cylinder pressures will be obtained when an emergency reduction of brake-pipe pressure is made from a fully charged brake system.

A power-brake system for passenger and freight trains should provide means whereby effective emergency brake-cylinder pressure will be obtained when emergency reduction of the brake-pipe pressure is made after a full service brake-pipe reduction has been made.

A power-brake system for passenger and freight trains should provide means whereby effective emergency brake-cylinder pressures will be obtained when an emergency reduction of brake-pipe pressure is made following release after a full service brake application.

A power-brake system for passenger and freight trains should provide means whereby the engineman can control the release of pressure from brake cylinders and effect such release by graduated steps or gradually in order that he may decrease as well as increase brake-cylinder pressure as required to control at relatively uniform rates the speed of trains.

A power-brake system for passenger and freight trains should provide for obtaining and maintaining brake-cylinder pressures within prescribed limits for specified periods of time during brake applications.

In addition to these general requirements it is clear that full specifications and requirements covering more fully the functions, maintenance, and operation of power brakes and appliances should be adopted. Consideration will be given to this and to the form of order to be issued by us. This case will be held open for that purpose.

Rail Equipment Sales Slump

The rehabilitation and aggressive re-entry of Western European rail equipment manufacturers into world markets is the principal cause for the $10,000,000 slump in values of American shipments of rolling stock, locomotives, air brake equipment and parts for the year ending June 30, 1924, in the opinion of the Transportation Division of the Department of Commerce. The prospects during the current fiscal year are much brighter, however, with every promise for recovery. New railroads are being constucted in Latin America, while old lines are adding to their equipment.

For the fiscal year ended June 30, 1924, 279 locomotives, valued at $4,188,236, were exported as compared with 276, valued at $5,307,075 in 1923. The earthquake in Japan was undoubtedly responsible for the largest single increase in locomotive exports, for 10 locomotives, valued at $83,672 in 1923, advanced to 33 locomotives, valued at $220,846 in 1924. The generally improved condition on Mexican Railways, particularly those of the National Railway System, was responsible for an increase of from 10 locomotives, valued at $120,728 in 1923, to 21 locomotives, valued at $154,416 in 1924. The outstanding sale of 1923, 28 locomotives, valued at $703,725, to the Polish Government was not of course expected to be repeated in 1924, and consequently this sum is the largest lost in exports to any particular country.

Electric locomotive exports increased from 48, valued at $2,758,191 in 1922-1923, to 74, valued at $1,955,646 during the last fiscal year.

The export of freight cars during the past fiscal year showed a decline of 6,760 cars with a value of $8,298,085 from the corresponding figures of 1922-1923, which disclosed shipments of 10,453 cars, valued at $11,729,962, as compared with 3,693 cars worth $3,431,877 in 1923-1924. Chile and Cuba are the only countries to show an increase in purchases from us, advances being 307 cars worth $409,590 and 67 cars valued at $147,711.

Miscellaneous exports of parts of cars (including car wheels and axles) increased from 78,938,308 pounds valued at $5,753,436 in 1922-1923, to 84,388,215 pounds valued at $6,221,427 during the last fiscal year.

The value of air brake equipment increased from $284,941 in 1922-1923 to $1,072,596 during the last fiscal year.

Car Building in Record Time

A crew from the Oneonta car shops of the Delaware and Hudson Railroad Company recently established what is believed to be a world's record by building a thirty-six ton box car complete in fifty-two man hours. Three hundred and fifty visitors representing the Delaware and Hudson System and twenty other railroads of the east, saw eight man crews from the Oneonta, Colonie and Crabondale, Pa., shops in the car building competition. The Oneonta crew built the car complete from materials to finished assembly in the total of six and one-half hours.

Equally as interesting is the record of two shop crews of the Atlantic Coast Line. Two ventilated and insulated thirty foot cars under a rebuilding program had all the material assembled beside the steel underframes, eight men were assigned to a car and these cars were completed in seven hours and forty-two minutes and seven hours and fifty-two minutes respectively. While this time is longer than the D. & H. record, it should be noted that the D. & H. put up a plain box car while the Atlantic Coast Line had full insulation including sub-floor, two solid and two ventilated side doors, four end ventilators, as well as being completely lined and ceiled inside.

The records referred to established the following points:

First—A crew of men efficient in the handling of all the details of the work, men who by experience knew how to take advantage of all the short cuts in the handling of the material from the ground and putting it together in the car.

Second—All necessary material made from blue prints of the car piled conveniently in the order in which it would ordinarily be applied, all bolts, nuts, washers, etc., in bins in which are marked with the size, thus insuring that no time would be lost in looking for such parts.

Third—Up-to-date tools in good condition and the proper place for the erection of the car which will insure the maximum of protection and comfort for the men while working.

Under above conditions while no such time will be made in the every day work as in this contest, yet a measuring stick is given of what is possible and with attention to the conditions a great improvement can be made in such work.

Larger and Better Cars and Locomotives

According to statistics assembled by the Car Service Division, American Railway Association, railways of Class I owned a total of 64,896 locomotives on January 1, 1924. This included passenger, freight and yard locomotives. The aggregate tractive effort of these locomotives was 2,541,914,000 lbs., an average of 39,169 pounds per locomotive.

On July 1, 1924, the same railways owned a total of 64,924 locomotives, with an aggregate tractive effort of 2,569,122,000 pounds, or an average of 39,571 pounds per locomotive.

In other words, although the number of locomotives on July 1 was only 28 greater than the number on January 1, the aggregate tractive effort had increased during the six months by 27,208,000 pounds, while the average tractive effort per locomotive had increased 402 pounds in the same period.

The reason for this increase is that the average tractive effort of the new locomotives installed during the six months was nearly 2½ times as great as the average tractive effort of the locomotives retired, the average for the new locomotives being 52,087 pounds compared with an average of only 22,416 pounds for the locomotive retired. The retired locomotives are of smaller and more absolete types.

The same general trend may be seen with respect to freight cars. On January 1, 1924, the total number of freight cars owned was 2,306,772, with an aggregate capacity of 100,459,021 tons, or 43.55 tons per car. On July 1, 1924, the total number of cars was 2,314,798, with an aggregate capacity of 101,569,594 tons, or 43.88 tons per car.

While the number of cars had increased by 8,026, or only a third of one per cent, the aggregate capacity had increased by 1,109,673 tons, or 1.1 per cent.

The average capacity of all the freight cars installed during the six months was 47.4 tons, compared with an average capacity for cars retired of 39.8 tons.

Notes on Domestic Railroads

Locomotives

The Montana, Wyoming & Southern Railroad has placed an order for one Mikado type locomotive with the Baldwin Locomotive Works.

The Seaboard Air Line Railway has placed an order for 30 locomotives, 20 Mikado and 10 Mountain type with the Baldwin Locomotive Works.

The New York, New Haven & Hartford Railway has placed on order with the American Locomotive Company for 10 three-cylinder eight-wheel switching locomotives, 0-8-0 type.

The Central of Vermont Railroad has ordered 2- 8,000-gallon tenders from the American Locomotive Company.

The California Fruit Exchange has placed an order for one Prairie type locomotive with the Baldwin Locomotive Works.

The West India Sugar Company has placed an order for one Mogul type locomotive with the Baldwin Locomotive Works.

The Duluth South Shore & Atlantic Railroad has placed an order for 2 Pacific type locomotives and 2 Consolidation type locomotives with the American Locomotive Company.

The Lehigh Valley Railroad has ordered 20- 12,000-gallon tenders from the American Locomotive Company.

The Villazon Atocha Railroad, Bolivia, has placed an order for one locomotive with the American Locomotive Company.

The New York Central Railroad has placed an order for 20 switch engines with the American Locomotive Company and 5 with the Lima Locomotive Works.

The Bangor & Aroostook Railroad has placed an order for 4 Consolidation type locomotives with the American Locomotive Company.

The Ferrocarril del Pacifico Railroad, South America, has placed on order for 2 Mountain type locomotives with the Baldwin Locomotive Works.

The Erie Railroad has ordered one Pacific type locomotive and one Mikado type locomotive from the Baldwin Locomotive Works.

The Enyati Railway of South Africa has ordered one 2-10-2 type locomotive from the Baldwin Locomotive Works.

The Cincinnati, Indianapolis & Western Railway has placed an order for 4 Pacific type locomotives with the American Locomotive Company.

The New York, New Haven & Hartford Railroad has ordered 10 0-8-0 switching type locomotives from the American Locomotive Company.

The Northern Pacific Terminal has placed an order for one switching type locomotive from the American Locomotive Company.

The Lourenco Marques Railway, Portuguese East Africa, has ordered 2 Mikado type locomotives from the Baldwin Locomotive Works.

The Knox Railroad has placed an order for one Prairie type locomotive with the American Locomotive Company.

Freight Cars

The Union Railroad is inquiring for 12 gondola cars of 70 tons capacity.

The Great Northern Railway is inquiring for 50 steel underframes.

The Carnegie Steel Co. has ordered 20 tank cars of 12,500-gallon capacity from the Standard Tank Car Co.

The San Antonio & Aransas Pass Railway is making inquiries for from 50 to 100 tank cars.

The National Refining Co., Cleveland, Ohio, has ordered 16 tank cars from the Standard Tank Car Co.

The Missouri Pacific Railroad has placed on order for 500 refrigerator cars with the American Car & Foundry Company.

The Swift & Co., Chicago, Ill., have placed an order for 100 steel underframes with the Western Steel Car & Foundry Company.

The Ford Motor Car Co. has ordered 7 tank cars of 12,500-gallon capacity from the Standard Tank Car Company.

The American Rolling Mills have placed an order for 6 gondola bodies with the Pressed Steel Car Company.

The Chesapeake & Ohio Railroad is inquiring for the repair of 500 gondola cars.

The Maine Central Railroad is inquiring for 250 box cars.

The International Railways of Central America have ordered 90 box cars of 20-ton capacity from the Gregg Car Company.

The Lehigh & New England Railroad is making inquiries for the repairs to 300 freight cars.

The Bell Oil & Gas Co., Tulsa, Okla., has ordered 3 insulated tank cars of 8,000-gallon capacity from the Standard Tank Car Co.

The Cambria & Indiana Railroad is inquiring for repairs on 200 hopper cars.

The Hershey Chocolate Co., Hershey, Pa., is inquiring for from 50 to 100 tank cars of 12,000-gallon capacity.

The Spokane, Portland & Seattle Railroad has placed an order for 60 logging cars 42 ft. long 80,000 lbs. capacity with the Magor Car Corp.

The Western Fruit Express has placed an order for 1,000 underframes with the American Car & Foundry Company.

The Union Refrigerator and Transit Company has placed an order for 500 refrigerator cars with the American Car & Foundry Company.

The Central Railroad of Brazil has placed an order for 50 refrigerator cars with the Middletown Car Company.

The Dewey Portland Cement Company is inquiring for 4 all-steel drop bottom gondola cars.

The Grand Trunk Railway is making inquiries for 25 underframes for caboose cars.

The W. R. Grace & Co., New York, are inquiring for 50 stock cars of 33-ton capacity for use on the Brazilian railways.

Passenger Cars

The Reading Company has placed an order for passenger cars as follows: 40 steel coaches, Bethlehem Shipbuilding Corporation; 10 steel baggage cars, American Car & Foundry Company; 10 steel combination cars, Standard Steel Car Company.

The Rio Grande Do Sol Railway of Brazil is inquiring for a large number of passenger cars.

The Rutland Railroad is inquiring for one 70 ft. combination passenger and mail car.

The Duluth Missabe & Northern Railway has ordered one coach equipped with Oneida power units from the Oneida Mfg. Company.

The Delaware, Lackawanna & Western Railroad has placed an order with the Pullman Company for 50 suburban coaches and with the Bethlehem Steel Corporation an order for 10 combination baggage and passenger cars.

The Seaboard Air Line is inquiring for 18 passenger cars of various types and 10 caboose cars.

The Virginia & Rainy Lake Railway has ordered one motor inspection car equipped with Oneida power units from the Oneida Mfg. Company.

The Baltimore & Ohio Railroad is inquiring for 80 suburban coaches.

The New York Central Railroad will build 28 horse cars in its own shops at West Albany, New York.

The Missouri Pacific Railroad has placed an order for three gasoline motor cars at a cost of $50,500 for branch line operation.

The New York, Chicago & St. Louis Railway has ordered one business car from the Pullman Company.

The Dansville & Mount Morris Railroad has placed on order with the Edwards Railway Motor Car Co. for one 50 passenger twin engine motor car.

Buildings and Structures

The Louisville & Nashville Railroad has awarded a contract covering the construction of a machine and forge shop at Corbin, Ky., to cost approximately $150,000.

The Northern Refrigerator Car Co. has awarded a contract covering the construction of a brick and steel car shop at Cudahy, Wis.

The Central Vermont Railway has awarded a contract to the Roberts & Schaefer Company, Chicago, Ill., for the construction of a 200-ton frame coaling station and cinder plant at Brattleboro, Vt.

The Atlantic Coast Line Railway is contemplating plans for the erection of a new shop at Savannah, Ga.

The Grand Trunk Railway has awarded a contract to Bierd, Lydon & Grandpre, Chicago, Ill., for the construction of a powerhouse, roundhouse, engine terminal and shops at Battle Creek, Mich., to cost approximately $600,000.

The Central Railroad of New Jersey has awarded a contract covering the construction of two buildings at its repair shops at Elizabeth, N. J., to cost approximately $100,000.

The Northern Pacific Railroad has plans for a one-story steam operated power plant at Brainerd, Minn., to cost more than $350,000, including equipment.

The Delaware, Lackawanna & Western Railroad has awarded the contract to F. D. Hyde, Inc., New York, for the construction of a roundhouse and yard improvements at Binghamton, New York, to cost approximately $1,250,000.

The Atlantic Coast Line Railroad has awarded a contract for the construction of 150-ton reinforced concrete electrically operated coaling plant at Fort Meyers, Fla., to the Roberts & Schaefer Co., Chicago, Ill.

The Baltimore & Ohio Railroad has awarded a contract for the construction of water-treating plant at Bridgeport, Ohio, to cost approximately $25,000.

The St. Louis-San Francisco Railway has awarded a contract for the construction of a power house and steam and air lines at its East Thomas Terminal near Birmingham, Ala.

The Southern Pacific Co. have completed plans for the construction of a freight car repair plant at Houston, Texas, and has awarded a contract to F. B. Chambers, Houston, Texas.

The Pennsylvania Railroad has awarded a contract to E. H. Reuss, Jr., for the installation of piping at its new shops at Juniata, Pa., to cost approximately $40,000.

The Great Northern Railway has awarded a contract to L. I. Stromsvold, Minot, N. D., for rebuilding ten stalls of the enginehouse at Williston, N. D.

The Pacific Fruit Express Company plans the construction of a car repair shop, paint shop at Nampa, Idaho, to cost approximately $450,000.

The Atchison, Topeka & Santa Fe Railway has awarded a contract for the construction of two additions to its locomotive shops at San Bernardino, Calif.

The Southern Railway has awarded to the Foundation Company, New York, a contract for the design and construction of the Sevier yard near Knoxville, Tenn. The work under the contract covers the construction of a classification yard, a 34-stall roundhouse, a machine shop, a power house, cinder pits, freight transfer sheds, offices, turntable, signal systems, and a large amount of track work, together with buildings, equipment, etc. The new classification yard will be about 3 miles long and will have a capacity of 2,929 cars.

The Western Pacific Railroad is asking for bids for an engine house to cost $70,000 and a machine shop to cost $40,000 to be erected at Stockton, Calif. The road engineering department is in charge of the improvement.

The Erie Railroad plans extensions to its car and locomotive shops at Avoca, Pa., including additional equipment.

The Western Maryland Railroad is planning the erection of new engine terminal at Dunbar, Pa., to replace the one recently destroyed by fire.

The Chicago, Rock Island & Pacific Railway shops at Shawnee, Okla., were damaged to the extent of $600,000 by fire which occurred on July 7.

The Southern Railway have started work on their new shops and yards at Caswell, Tenn. It is estimated that the cost of this improvement will be approximately $2,000,000.

Items of Personal Interest

S. P. Alquist, formerly master car builder of the Pere Marquette Railway, has been appointed master car builder on the Delaware, Lackawanna & Western Railroad, with headquarters at Scranton, Pa., succeeding **J. C. Fritts**, resigned.

James P. Egan has been appointed superintendent of car inspection of the New York, New Haven & Hartford Railroad, with headquarters at New Haven, Conn. **H. W. Maxwell** has been appointed master mechanic of the Boston division, succeeding Mr. Egan. **W. C. Squires** has been appointed master mechanic at East Hartford, Conn., succeeding **L. G. Marette**, resigned.

R. H. Hale, master mechanic of the Alaska Railroad, has been promoted to superintendent of motive power with headquarters at Anchorage, Alaska, and the office of master mechanic abolished.

W. F. Heinbach, master mechanic of the Philadelphia & Reading Railway, with headquarters at Philadelphia, Pa., has been appointed master mechanic of the Reading and Harrisburg division, with headquarters at Harrisburg, Pa., succeeding **G. A. Dugan**, resigned.

G. S. West, general foreman of the Cumberland Valley division of the Pennsylvania, has been appointed assistant master mechanic of the Meadow shops, New York division, succeeding **J. A. Sheedy**, promoted.

William Fite, fuel supervisor of the Cincinnati and Northern divisions of the Chesapeake & Ohio Railway, has been promoted to assistant road foreman of engines of the same divisions, with headquarters at Russell, Ky.

William O. Forman, assistant mechanical superintendent of the Boston & Maine Railroad, has been promoted to mechanical superintendent, with headquarters at Boston, Mass., succeeding **Mr. Wiggin**, who has been appointed consulting mechanical engineer, with the same headquarters.

Stephen I. Palmer, traveling engineer of the Trenton Division of the Pennsylvania Railroad, has been appointed assistant road foreman of engines of the same division, succeeding **B. W. Steelman**, deceased.

G. W. Lloyd, assistant road foreman of engines of the Chesapeake & Ohio Railway, with headquarters at Russell, Ky., has been transferred to Covington, Ky.

C. J. Wiard, division foreman of the Chicago, Rock Island & Pacific Railway, with headquarters at Caldwell, Kans., has been appointed general foreman, with headquarters at El Reno, Okla., succeeding **J. W. Finch**, resigned.

P. Kass, general foreman car department of the Chicago, Rock Island & Pacific Railway, has been promoted to superintendent of the car department, with headquarters at Chicago, Ill., succeeding **E. G. Chenoweth**, who has been granted leave of absence.

F. D. Wright has been appointed general roundhouse foreman of the Erie Railroad, with headquarters at Hammond, Ind., succeeding **W. H. Williams**, deceased.

T. V. Robinson has been promoted to car foreman of the old shop of the Missouri Pacific Railroad, with headquarters at Sedalia, Mo.

W. A. Bender, general foreman of the Chicago, Milwaukee & St. Paul Railway, with headquarters at Green Bay, Wis., has been appointed superintendent of shops of the Missouri Pacific Railroad, with headquarters at St. Louis, Mo.

Supply Trade Notes

The Truscon Steel Company has moved its Chicago office to 165 E. Erie Street, Chicago, Ill.

The Fairmont Railway Motors, Inc., has opened a branch office at 637 Mission Street, San Francisco, Calif. **R. W. Jamison** has been appointed district sales manager.

The Ulster Iron Works, Dover, N. J., has opened an office at 52 Vanderbilt Avenue, New York City.

J. V. Miller, formerly storekeeper of the Chicago, Milwaukee & St. Paul Railway, has been appointed sales representative of the **Prime Manufacturing Company,** with headquarters at Milwaukee, Wisc.

The Industrial Works announce the opening of a new district office at Monadnock Bldg., San Francisco, Calif., in charge of **J. M. McGuire,** district sales manager.

Clyde P. Ross, contracting manager of the **Roberts & Schaefer Company,** Chicago, has been appointed third vice-president.

W. M. Ryan, formerly president of the **Ryan Car Company,** has been elected president and member of the board of directors of the **Youngstown Steel Car Company,** Niles, Ohio. Mr. Ryan succeeds **Mr. Wilkoff,** who is retiring from active business duties, but remains a member of the board of directors.

The Union Metal Products Company, Chicago, has acquired the plant of the **Keith Railway Equipment Company,** Hammond, Ind. The Keith interests will operate their tank car line as heretofore.

The Northern Refrigerator Car Company, Cudahy, Wisc., has given a contract for the construction of one-story brick and steel car construction and service shop to **Worden Allen Company,** Milwaukee, Wisc.

Cleon M. Hannaford has severed his connection with the Chesapeake & Ohio Railway Co., and will devote his entire time to the railway supply business as president of the **Car Device Company, Inc.,** Richmond, Va., which he organized.

The Grip Nut Company, Chicago, has acquired a tract of land on which it will lay out an 18-hole golf course, which may be used by employees and visitors to the factory.

C. A. Fisher has been appointed district representative of the **Central Iron & Steel Company,** Pittsburgh, Pa., with offices at Keystone building, Houston, and also Wagoner building, Fort Worth, Texas.

The National Malleable and Steel Castings Company plans the construction of a one-story foundry at Indianapolis, Ind., of reinforced concrete and steel, estimated to cost $100,000.

The General Electric Company, announces that it will build a 5-story office building and warehouse in Cincinnati, Ohio. The building will cost about $500,000 and will be erected on a lot at Third Street and Mulberry Alley. It is also reported that the company will spend a similar amount for a new plant.

W. A. Cather, formerly in charge of advertising and sales promotion for the **Worthington Pump and Machinery Corporation,** has been made sales manager of **Barrett Haentjens Company,** maker of centrifugal pumps. He will be located at the company's plant in Hazelton, Pa.

The Western Electric Co., Hawthorne, Ill., will occupy a new three-story building, 85 x 130 ft., to be erected at Seattle, Wash., for a new factory branch and distributing plant, estimated to cost $150,000.

R. J. Young has been appointed general sales manager of the **Canadian Car & Foundry Co., Ltd.,** succeeding **D. R. Arnold,** who has accepted a position with the **Union Metal Products Co.,** Chicago, Ill.

Obituary

Benjamin G. Lamme, Chief Engineer of the Westinghouse Electric and Manufacturing Company, and one of the world's leading electrical authorities, after a lingering illness of several months, died at his home, 230 Stratford Street, East Liberty, Pa., where he lived with his sisters, Miss Florence A. Lamme and Miss Lenna G. Lamme.

George Westinghouse, with whom Mr. Lamme was closely associated until Mr. Westinghouse's death, had perfected the alternating current system, by which electricity could be transmitted over great distances economically. Mr. Lamme then perfected railway and industrial motors and synchronous converters to make this alternating current useful at any point, and thus the use of electricity was removed from small, restricted areas and its use made universal.

His most spectacular achievements were the designing of generating equipment for the World's Fair in Chicago in 1892; 5,000 h. p. generators, a world's record at the time, when Niagara Falls was first harnessed for waterpower; generating and motor equipment for the first big railway electrification, that of the New York, New Haven & Hartford Railroad; the present day single-phase alternating current, high voltage railway system, which is responsible for most of the railroad electrifications; the design of the most successful synchronous converter ever used; and the single reduction gear street car motor, which though designed in 1890 is the type still used on street railway systems.

B. G. Lamme was born on a farm near Springfield, Ohio, January 12, 1864. He entered Ohio State University in 1883 and graduated in mechanical engineering in 1888, having been out of school during the year 1886-1887, on account of his father's illness and death. He had but little opportunity to study electricity, as there was no electrical engineering course at that time. He entered the employ of the Westinghouse Electric Company in 1889.

In the summer of 1890 Mr. Lamme began work on the design of a street car motor with but a single gear reduction. This was the forerunner of the celebrated Westinghouse No. 3—a motor that set a standard for street car motors that still persists. It was radically different from anything that had appeared previously, and its success when put out early in 1891, was instantaneous.

His great work on the synchronous converter, however, he regarded as one of his greatest achievements. For years, he fought the battle for the synchronous converter almost single-handed. He won out, as usual, and this is now the accepted machinery for converting alternating into direct current.

Then came his conception of the single phase alternating current railway system. He had long held the belief that the success of heavy electric railroading lay in the use of a high voltage alternating current on a single overhead trolley. He felt that the simplicity and advantage of this system with its simple sub-stations containing nothing but lowering transformers and with no attendants required, were so great that it must come. The main difficulty lay in finding suitable ways and means for utilizing the single phase alternating current. After several attempts, Mr. Lamme succeeded in designing a series commutator type of motor with suitable characteristics, which he described along with the system of power distribution in his famous paper before the American Institute of Electrical Engineers.

Mr. Lamme was not a prolific writer, but when he did write, the engineering world sat up and took notice. He had the happy faculty of being able to put his thoughts on paper so that anyone with the rudiments of the subject could understand them. One of his greatest assets was his ability to get a physical conception of every problem and he aimed to give that in his paper. He seldom wrote mathematical papers, although not far lack of ability, but he regarded mathematics as his tools that were to be put away when the work was done. Consequently, his papers are in great demand and are very widely read.

Mr. Lamme has received the highest honors from the American Institute of Electrical Engineers, in being elected one of the two members from that body on the Naval Consulting Board during the War and being chairman of the inventions committee on that Board. In 1919, he was also awarded the Edison Medal by the American Institute of Electrical Engineers for his engineering achievements. All of these were in consequence of his work and ability as an engineer—he was in competition with engineers only. When the Board of Trustees of Ohio State University awarded him the Joseph Sullivant Medal, it was a recognition of the value of his work to the world.

His greatness as an outstanding electrical engineer can best be judged by the eagerness with which engineers always sought his opinion and discussion.

H. A. Irwin, Far East Representative of the Landis Machine Company, Landis Tool Company, Warner & Swasey Company, and Kearney & Trecker Company, died in Tokyo, Japan, on Sunday, June 22.

Mr. Irwin was in this country during the early part of 1923 and prior to his departure to Japan was married to Miss Wills of Philadelphia. He is survived by his widow, who is at present in Japan, his parents and several brothers and sisters, who reside at McConnellsburg, Pa.

Mr. Irwin was for a long period of years direct representative of the Landis Tool Company in Europe. He traveled extensively through France, Italy, Germany, Belgium and England. About four years ago he became connected with the four companies, by whom he was employed at the time of his death, as representative in the Far East. He traveled in Japan, China and India in the interest of his principals.

W. F. Weller, assistant to the vice-president in charge of engineering of the American Locomotive Company, died on June 26, in New York City. Mr. Weller entered the service of the Richmond Locomotive Works in 1896 as secretary to the president, Joseph Bryan. Later, upon the formation of the American Locomotive Company he went to New York as assistant to Mr. Sague, mechanical engineer of the company. He remained in that position until Mr. Sague resigned, since which time he has served as assistant to the vice-president in charge of engineering.

Locomotive Superheaters.—"Origin, Development, Results of Elesco Locomotive Superheaters" is the subject of a booklet just published by The Superheater Company of New York and Chicago. It gives in brief form the history of The Superheater Company, starting with the introduction of Schmidt Superheaters in this country and through the development of Locomotive Superheaters and Locomotive Feed Water Heaters to their present position in this country. There is a chart in the middle of the booklet which shows the growth of the use of locomotive superheaters given by years from a mere handful in 1910 to a total of over 45,000 by the end of 1923. It is interesting to note that approximately one-third of the superheaters have been applied to existing locomotives. There is a paragraph explaining the adoption of the Trade Name "ELESCO," as applied to superheaters, feed water heaters and other products.

A copy of this booklet will be sent to anyone mentioning this publication.

Westinghouse Railroad Data.—There has for a long time been a need for concise and definite information regarding electrical applications on steam railroads. Special Publication 1707—Westinghouse Railroad Data—just issued by the Westinghouse Electric & Manufacturing Company, will go far toward filling this need.

This publication is 5¾" x 6¾", is in loose leaf form and the pages are assembled into a flexible cover. The subjects covered include sheets 1 to 10 inclusive of two pages each devoted to outline drawings and data on specific electric locomotives. Sheet 11 is a tabulation of data on representative modern steam locomotives. Sheet 12 is a complete tabulation of data on electric locomotives of North and South America. Sheet 13 includes information and curves or train resistance. Sheets 14 to 20 comprise a section devoted to information and data on arc welding; Sheet 22 to wheel lathe equipment and direct current reversing motor planer equipment; Sheet 23 to turntables and transfer tables; Sheet 24 to data on general motor application; Sheet 25 to power factor correction, and Sheets 26 and 27 to general data on weights and specific gravities, conversion factors, etc.

The pages in this publication are punched so that they can be removed from their present flexible cover and placed in standard I. P. ring binders or assembled with regulation Lefax data. Many of the sheets include four and six pages folded. Copies of this publication may be obtained free of charge from the Westinghouse Company.

Locomotive Feed Water Heaters.—The Superheater Company of New York and Chicago has just issued a second edition of this instruction book, covering shop and enginehouse maintenance for the Elesco Locomotive Feed Water Heater. It gives detailed instructions covering inspection and testing, cleaning the heater, heater repairs, and pump repairs. Two charts in the center of the book illustrate by means of the passage of steam and water through the different parts of the equipment. An added feature of this edition of the book is the order list covering feed water heater parts on folded inserts in the back of the book.

A copy of this book will be gladly sent to anyone mentioning this publication.

Exhibition Tests of Chicago, Milwaukee & St. Paul Passenger Locomotive and 3,000 Volt Multiple Unit Train. By the General Electric Co., Schenectady, New York.

In the issue of **Railway & Locomotive Engineering** for April, 1920, a description was published of the electric locomotives that had been built for the Chicago, Milwaukee & St. Paul Railway by the General Electric Co. In May last the exhibition tests set forth in this pamphlet were conducted on the experimental tracks of the company at Erie, Penna. There was also an exhibition of a 3,000 volt multiple unit train. There is a description of the train, the method of gearing the motors to the axles and the control, the heating equipment and other details.

The under bridge current collection, the hornless pantagraph and the otheograph tests are also included. In dealing with the latter a number of illustrations of records are given, some being identical with those published in **Railway & Locomotive Engineering** for June, 1924, in connection with a description of the otheograph apparatus.

New Haven Electrification.—A new 48-page publication has just been produced jointly by the New York, New Haven & Hartford Railroad and the Westinghouse Electric & Manufacturing Company, covering in an interesting manner the entire New Haven Electrification.

Following a foreword by Mr. C. L. Bardo, General Manager of the New Haven, there is an introduction sketching briefly the historical developments which led up to the organization of the New York, New Haven & Hartford Railroad in 1872. The first chapter of the book is devoted to a story of the early branch line electrification experience of the company from 1895 to 1906.

Chapters 2, 3, 4 and 5 are devoted respectively to a description of the Track and Overhead System, Power Generation and Distribution, The Signal System, and Locomotives and Multiple Unit Cars. Chapter 6 goes into some little detail regarding equipment maintenance practice and shop facilities, while Chapter 7 describes the service rendered by the New Haven and the results which have been achieved by electrification. On a final page is a brief summary of the important facts regarding the electrification.

The new book, which is known as Special Publication 1698, under the title New York, New Haven & Hartford Railroad Electrification, is printed in the standard 8½ x 11 size on India tinted stock and is very completely illustrated by 70 photographs and drawings. Copies may be obtained free of charge from either the Westinghouse Company or the New Haven Railroad.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

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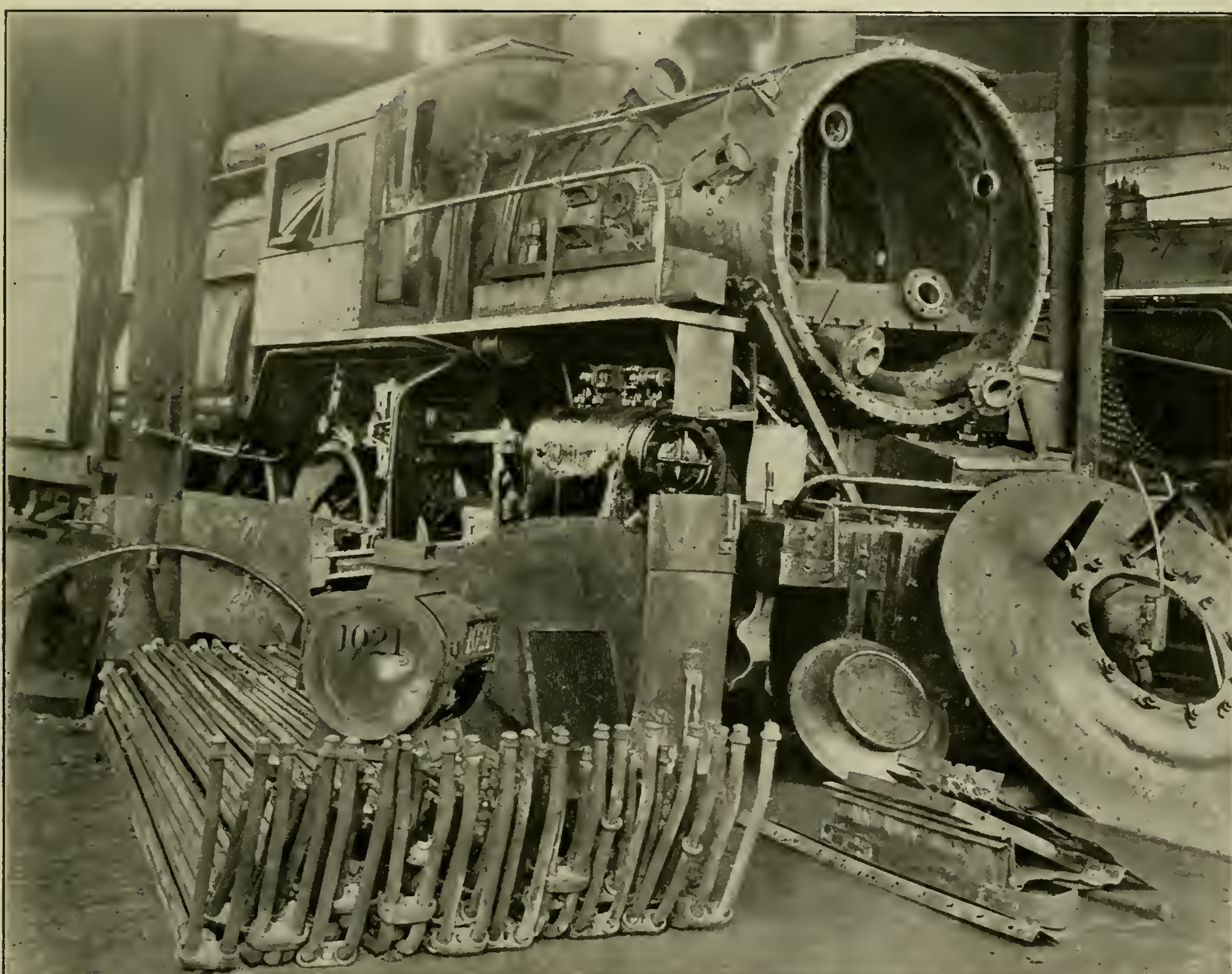
The Inside and Outside Drypipe

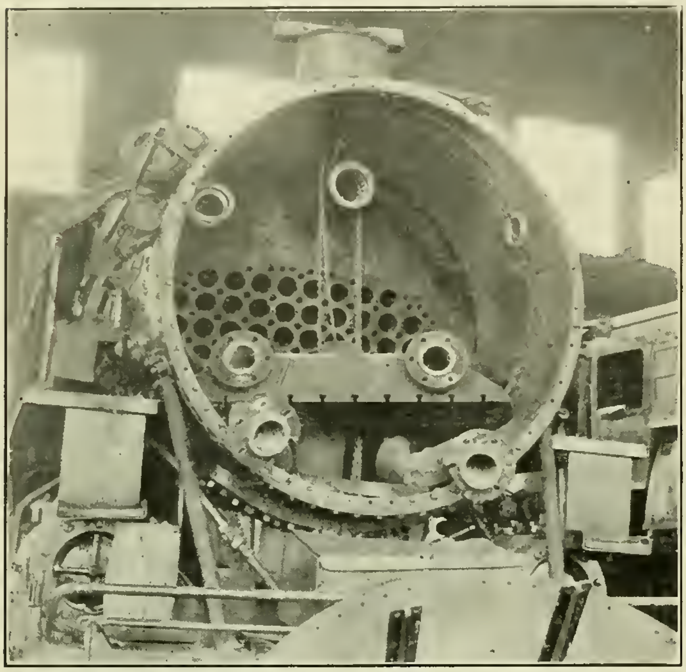
The Persistence of the Inside Type and a Reason for Abandoning it

It is, at times, interesting to note the persistence of an old idea or old form of construction for many years after the reasons for its origin have ceased to be of value. It is like the survival of the buttons on the sleeve of a man's coat. However useful they may have been, when first applied, that usefulness has long been buried with the past. And so it seems might be said of the inside drypipe of a locomotive boiler.

In the days when some of us were younger than we are now, and when a good big boiler had a shell diameter of 48 in., when there was plenty of clearance for a good high dome, and there was nothing in the smoke-



Engine as Dismantled to Regrind Dry. Pipe Connection box but the petticoat, steam and exhaust pipes, it was natural, efficient and convenient to run the drypipe through the top of the shell and the front tubesheet and there attach the steam pipes. If anything happened to it, there was nothing to remove at the front end in order to get access to it but the steam and petticoat pipes, and these, with the niggerhead, merely required the loosening of a few bolts and nuts. And yet with this simple arrangement, the making of drypipe and niggerhead joints was looked upon as one of the worst jobs to come into



Smokebox Showing Superheater Header Removed in Order to Regrind Dry Pipe Connection

the engine house, as it always meant taking the engine out of service for a considerable length of time, tying up a number of mechanics who were needed to make good ordinary wear and tear, and the utilization of no small portion of the payroll allotment for work.

A well known bridge builder once said that a bridge should be so constructed that any part could be removed and replaced without disturbing anything else. It is a good rule to apply to all mechanisms. Accessibility and ease of repairs are overlooked by the majority of designers who have not had the good fortune to have been brought up in that university offering unparalleled advantages for experience and observation, the repair shop. So they adhere to old designs quite forgetful of the man in the roundhouse whose duty it will be to maintain and repair the machine.

Consequently the well and appropriately designed drypipe of the diamond stack days, has held its own by mere force of inertia, while the smokebox has been filled with netting and diaphragms and valves and pipes and superheater headers and blowers and every sort of fixed and motionless thing, all in front of and preventing access to the dry pipe until it is as inaccessible as the subfoundations of a bridge pier.

But the ball joints and connections of this conduit are apt to leak and when they do, there must be a general dismantling of the whole front end in order to make repairs. And now enters the subject matter of our thesis.

We are indebted to Mr. John E. Muhlfeld for the photographs of the dismantled parts of a front end, from which the engravings are made, the contemplation of which led him to the use of the outside drypipe on the Kansas City Southern Mallet locomotives which will be referred to later. These illustrations show the parts that it was necessary to remove in order to repair a leaky drypipe in a modern locomotive.

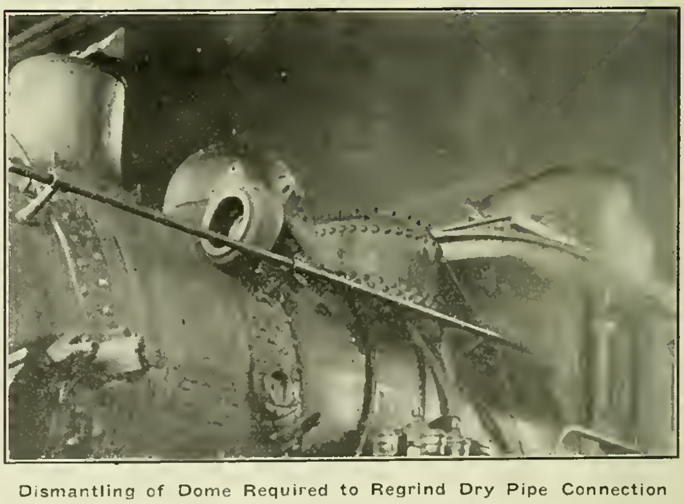
The first page illustration shows the dismantled smokebox, from which the front and door had been removed, and with them the headlight, petticoat pipe or inside stack, netting, baffle plates and fittings, superheater elements, header, steam regulator and other parts necessary in order to do the work of regrinding a leaky drypipe joint at the front tubesheet connection. Surely it would be difficult to imagine a more complete wreck than the necessity of doing this comparatively insignificant piece of repair work has entailed on the front end.

A second illustration gives a front view of the smokebox and drypipe partially dismantled and also the dismantled superheater header and the drypipe drawn forward from its normal position.

The third illustration shows that the front end is not the only point of attack in this dismantlement, for the drypipe must also be freed from its dome connections, and we have the dismantled dome with its casing on top of the cab, its throttle stand-pipe removed and in a temporary resting place on the hand rail, and with the throttle valve removed, and its connections severed.

And all this to make what Mr. Muhlfeld calls "unproductive" repairs, that should not be required between classified repairs. In this particular case, to make good the leaky drypipe joint, represented work equivalent to the time of two men for a period of two weeks.

On the other hand, if a crosshead, a wedge or a brass wears, it is a case of legitimate deterioration that, when repaired leaves the engine in better condition than it was. But a drypipe leakage must be repaired, yet it is not a matter of ordinary wear and tear. At least, under the conditions of modern locomotive construction, the necessity for repairing a leak at the front connection of an inside dry-



Dismantling of Dome Required to Regrind Dry Pipe Connection

pipe is a thing to bring consternation to the roundhouse forces.

Now what are its advantages as compared to the outside pipe? It has a natural jacketing of hot steam to protect its contents, it is out of sight and the wisdom of our ancestors is in the construction, and designers seem to think that it is not for their unhallowed hands to disturb it, or the country's done for, and "use doth breed a habit in a man."

The outside drypipe is not a novelty, in Europe at least, and the outside receive pipe of the Mallet compound is beginning to get a touch of grey on the temples. It is, therefore, nothing to be afraid of. It may also be confessed that it is not a thing of beauty and that, as far as appearances go the invisible inside pipe has it at a disadvantage, but "handsome is as handsome does," and the outside pipe has merit of its own as will presently appear.

Taking for an example of accessibility, convenience and effectiveness, the outside drypipe used on the Mallet locomotives of the Kansas City Southern is here illustrated. A clear idea of its general appearance can be obtained from the reproduction of the photograph of the locomotive to which it was applied. It may be frankly acknowledged that it does not add anything to the beauty or smoothness of outline of the locomotive. But neither do any of the other excrescences that have been attached to the boiler since the days of the crosshead pump and the high dome.

Starting at the dome, it departs from the usual construction in that it is a steel casting, with a flanged side opening to which the first section of the drypipe is bolted. This side opening terminates, on the inside of the dome in a cup *I* the upper edge of which is 4 in. below the inside of the dome cover and 11½ in. above the top of the shell of the boiler. This insures that the steam flowing into the drypipe is as dry as it is possible to obtain.

The first section of the drypipe *B* which is bolted to the dome is only 16½ in. long and is in the form of a stuffing box to form an expansion joint. Its connection to the dome is made by means of a ball joint of the ordinary construction and located at *C*, the details of the construction not being shown. The gland *D* is bolted to the stuffing box and holds the packing about the sleeve. The sleeve *E* is 37 in. long and 8½ in. inside diameter which is that of the other cast sections drypipe. The length of the stuffing box section and the sleeve from face to face of their flanges is 44 in.

The sleeve is carried on a support *F* bolted to the shell of the boiler, that is so aligned with the expansion joint that the sleeve will move freely to and fro in it.

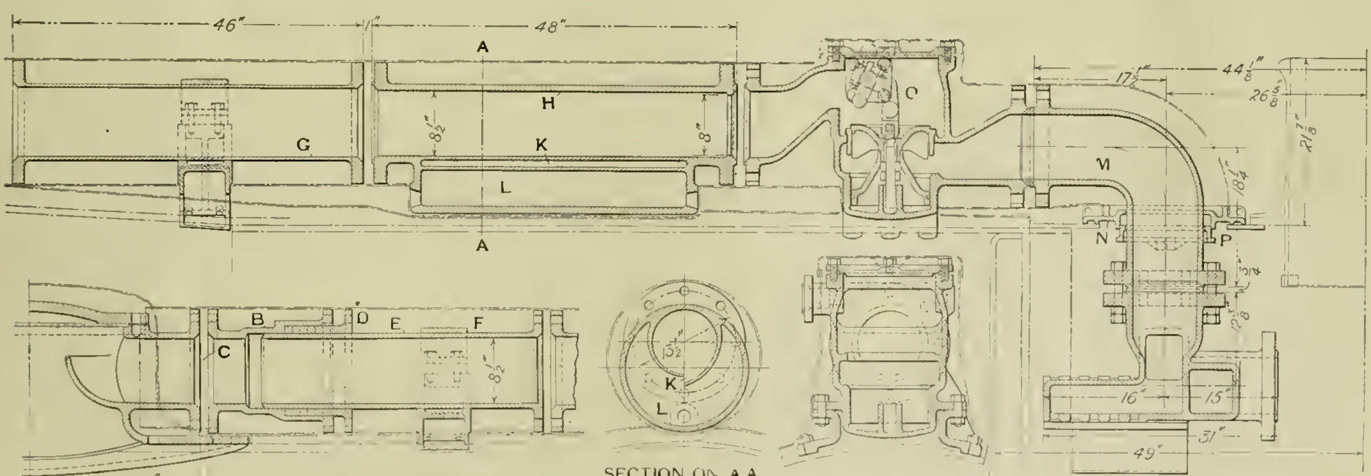
The next section *G* of the pipe is of wrought iron with the flanges welded on and is of the nominal 9 in. inside diameter. This length, which is 46 in. long is carried on a support similar to that used for the sleeve.

Then comes the last length which is cast and takes the form of a moisture extractor. This is also shown in section at *AA*. The water that is entrained with the steam as well as that of condensation, especially that formed in the pipe when the throttle is closed, falls to the bottom and flows out through the opening *K* from which it drains directly back into the boiler. This is through the pipe shown on the photograph leading back from the extractor and entering the boiler on the right hand side just ahead of the steam dome. It is filled with a balanced check valve opening towards the boiler so that no steam or water can rise from the boiler into the extractor, while the static head of the water that accumulates in the latter is sufficient to open it and permit this water of condensation to flow down into the boiler. With this arrangement there is no loss of water and only that heat loss which results from radiation.

The throttle valve is also on the outside and stands next to the extractor, and has its front flange about flush with the flange of the front tubesheet.

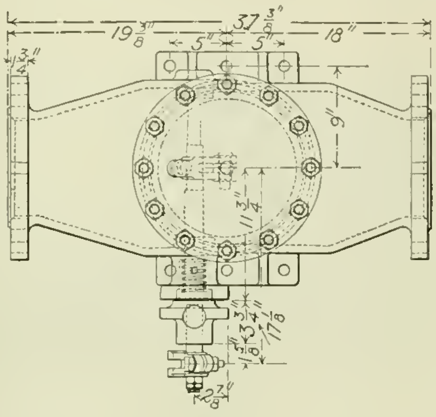
Beyond the throttle valve casing there is an elbow *M* which turns and enters the smokebox just back of the stack. In doing so it passes through a stuffing box *N* which is made in two parts to permit of assembling, and is made tight by a packing of asbestos rope held in place by the gland *P*. At the lower end the elbow section is

Mallet Locomotive, Kansas City Southern Railway With Outside Dry Pipe



Outside Dry Pipe Used on Kansas City Southern Railway Mallet Locomotive bolted to the top of the superheater header with a ball joint connection. A similar connection being made between each of the sections of the drypipe.

The throttle casing is bolted to the front course of the shell just back of the front tubesheet and it, too, is a steel casting. The valve itself is of the balanced piston type and its lifting link *O* is so arranged that it will strike against the inside of the cover of the throttle casing, as



Plan of Throttle Valve for Outside Dry Pipe

indicated by the dotted lines, when the valve is fully opened.

The operating arms to which the throttle rod and the lifting link are attached are clamped to the shaft and have a movement through an angle of about 30°.

Each length of pipe is protected by sectional lagging held in place by an outside jacket. At the bottom where the drip of the water extractor is located, a depression is made in the jacket of the shell but with this exception and that of the throttle valve casing which is brought down close to the shell, the packeting of the drypipe is high enough to clear that of the boiler.

Now turning back to consider the arrangement from the standpoint of accessibility for the repairman, it will be seen to meet all of the requirements set forth by the bridge builder alluded to, that any one part can be removed, repaired and replaced without disturbing any of the other parts. This holds for the whole. If the dome cracks it can be removed if necessary and repaired without disturbing any section of the drypipe. So of any section, including the throttle casing and the elbow, while as for the throttle valve itself it becomes accessible in every part when the cover for the casing has been removed.

Against this there are six ball joints each with two ground surfaces to make and maintain as against two for the inside pipe.

This will add somewhat to the original cost of the drypipe as compared to one on the inside, but the saving effected by the convenience of handling in the case of repairing and regrinding a single joint will probably more than equal the extra cost of the whole pipe.

Much is being said in regard to the lack of engine house and shop facilities of the railroads throughout the country to properly care for the modern locomotive in its inspection and maintenance requirements. But if more attention were to be given to details of this kind in the designing of new locomotives, it would greatly assist in cutting down the amount of labor required of the roundhouse forces, and result in both a reduction of expense and an improvement in the condition of the locomotives.

Temperatures in Cabs of Freight Locomotives Passing Through Tunnels of the Chesapeake & Ohio Railroad

By S. H. Katz and E. G. Meiter

Railroad locomotives produce heat, gas, and smoke, which cause considerable discomfort to engine men and firemen while passing through tunnels. In order to try and improve these conditions, the Bureau of Mines has investigated the composition of atmospheres in cabs of freight locomotives while in tunnels; and some of the higher temperatures in the cabs were noted; physiological effects upon men were determined and gas masks and respirators were devised to eliminate the effects of irritating and poisonous gases and smoke. These investigations were conducted in tunnels of the Baltimore & Ohio, Pennsylvania, and Union Pacific railroads; while that described in this paper was carried out in tunnels of the Chesapeake & Ohio Railroad, situated in the Blue Ridge and Allegheny Mountains in Virginia and West Virginia. Freight locomotives used by this railroad are of the Mallet type.

It has been suggested as a means of securing greater power units that Mallets be constructed to operate only as simple engines. This would increase the amount of steam given off as well as the amount of coal burned and the resulting volume of flue gas emitted.

Heretofore the high temperatures in cabs were attributed principally to exhaust gases and steam, and in the present tests especial effort was made to determine the temperatures at different positions in the cab and the relative effect of the exhaust gases and heat of the boiler in causing discomfort. It was found that stack gases entering the cab cause only a little increase in temperature; the increased humidity is principally due to steam carried in the stack gases; the exposed part of the boiler, however, play an important part in raising the temperature in the cab.

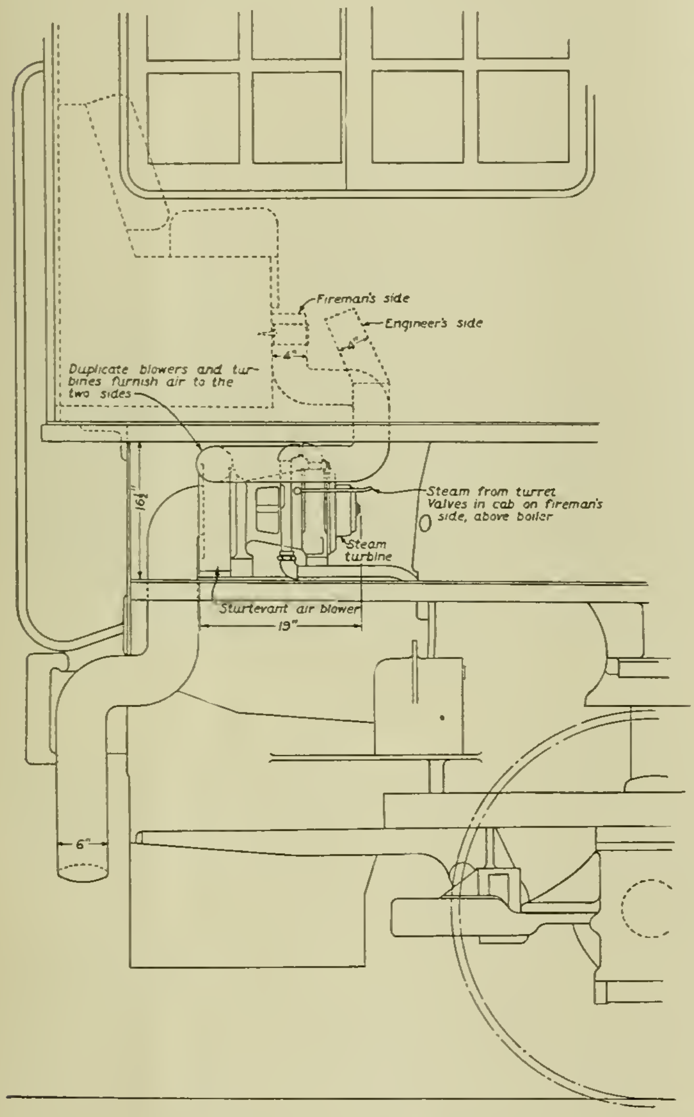
Efforts were made to increase the comfort of the engine crew by blowing cool and smoke-free air upon them by means of specially installed blowers from a point 24 inches above the center of the rails between the locomotive and tender, as shown in the illustration. The enginemen and firemen found this air better to breathe, and their feeling of comfort was increased somewhat thereby. Turbulence produced by the incoming streams caused the air in the cab to impinge upon the boiler and become heated, so that outside of the direct line of the air streams little cooling was felt, and sometimes the discomfort seemed to increase.

The ill-effects and discomforts due to heat and gas may, of course, be eliminated by forced ventilation of tunnels or by substituting electric for steam locomotives, but such changes are outside the scope of this paper.

Ventilating Fans for Locomotive Cabs

On account of the high temperatures, smoke and irritating gases which cause the difficult breathing experienced by crews of freight trains in tunnels, George W. Bebout, electrical engineer for the C. & O. R.R. proposed blowers or fans for ventilating cabs with pure cool air drawn from a position low in the tunnels. A trial installation was built on Mallet locomotive No. 840 by J. J. Ewing, engineer of tests. The illustration shows details of the steam turbine, blowers, and connecting pipes, all of which were mounted on the frame beneath the cab floor, one complete unit on each side of the locomotive.

Similar blowers for ventilating cabs of freight locomotives are being used in tunnels of the Norfolk and Western R. R. They are reported as being satisfactory. The



Ventilating Blower for Locomotive Cabs

Southern Railway also has used them but does not favor them, partly because of maintenance requirements.

As previously stated, the intake air is drawn from a point about 24 inches above and midway between the rails, through 6-inch galvanized sheet iron pipes, to a Sirocco type rotary blower capable of delivering 1,000 cubic feet of free air per minute. The discharge pipes, 4 inches in diameter, terminate at points 12 inches above the floor in front of the cab seats, and direct the air streams at the positions of the fireman and engineer. The blowers were driven at 3,600 r.p.m. by small, direct-connected steam turbines, like those used for driving electric generators for the headlight. The turbine, blower, and base plate occupy a space approximately 16 by 19 by 16 inches high.

Steam valves for the turbine were placed above the boiler in the cab with wheels arranged for convenient operation by the fireman.

Exact measurements of the volume of air delivered by the blowers were not made, but it was estimated to be more than 500 cubic feet each per minute, or enough to replace the cab atmosphere at least twice a minute.

Description of Tunnals

Tests were conducted in 19 tunnels between Charlottesville, Va., and Minton, W. Va., a distance of 175.6 miles.

This includes two districts, each of which constitutes a "run" for locomotive and crew. In the Mountain district, from Charlottesville to Clifton Forge, Va., a distance of 96.3 miles, are eight tunnels, all single track. In the Allegheny district, between Clifton Forge, Va., and Hinton, W. Va., a distance of 79.3 miles, are eleven tunnels, three of single track and eight of double track.

The eight tunnels in the mountain district varied from 100 ft. to 4,263 ft. in length and with one exception the grades ranged from 687 ft. to 78 ft. to the mile; the one exception being a tunnel 355 ft. long that was level. All of the grades were ascending upward, to the west, with two exceptions, and these were 389.5 ft. and 1,335 ft. long respectively. The smallest tunnel had a height of 15 ft. 9 in. above the top of the rail and a width of 13 ft. This was 864 ft. long on an ascending grade westward ranging from 70 ft. to 75 ft. per mile. Even the longest tunnel was only 18 ft. high and 13 ft. 6 in wide.

In the Allegheny district the tunnels are longer but the gradients are easier. The longest is 6,478.7 ft. long, but this tunnel is fitted with the Churchill ventilating system blowing from east to west. This has an ascending grade to the west. Another tunnel 667.5 ft. long having an ascending grade to the east is also fitted with this system of ventilation. There are two tunnels of more than 4,000 ft. in length, one with an up grade to the west and another with one to the east. The grades of the unventilated tunnels run from 20 ft. to 60 ft. to the mile; their heights vary from 16 ft. to 25 ft. 8 in. above the rail with widths of from 14 ft. 6 in. for the single track to 27 ft. for the double track.

The Blue Ridge tunnel in the Mountain District, 4,263 ft. long, with a grade westward of 68.7 ft. per mile (1.3 per cent) is worst for westward trainmen; while the Millboro tunnel, 1,335 ft. long, with a grade eastward of 74 ft. per mile (1.4 per cent) is worst for eastbound trainmen. The double-tracked tunnels of the Allegheny District have much greater clearance than single-tracked tunnels, and are more comfortable as a rule. Of the tunnels on the Allegheny district the worst eastbound is Second Creek tunnel and westbound is Big Bend tunnel; both are single track tunnels. Big Bend tunnel is 6,478 feet long with grade from both ends to a point 1,500 ft. from the eastern portal. It is provided with a ventilating fan for blowing eastbound trains but not for westbound trains; despite a slight descending grade westbound it is necessary to work steam so that Big Bend tunnel westbound is the worst in the district. Lewis tunnel, although it is 4,019 ft. long and single tracked on a grade westbound of 60 ft. per mile (1.1 per cent), is not uncomfortable since it was provided with a large ventilating fan for blowing westbound trains; trains drift through it eastbound. Allegheny tunnel on the west side of Allegheny Mountain is long, nearly a mile, but it is double-tracked and gives little trouble from heat and gas.

Investigations were conducted with five trains taken at random, having a tonnage ranging from 560 to 3,623 tons.

Four of the tests were on locomotive No. 840, on which were the ventilating blowers, as described. At the time of trip No. 4 from Charlottesville to Clifton Forge, this engine went without load, so that this test was made on locomotive No. 780, which followed with the next train.

Both locomotives were of the Mallet type. No. 840 alone weighs 437,000 pounds, and with the tender, 614,000 pounds. Its length is 63 ft. 10½ in., and 89 ft. 4¼ in. overall with tender; and height 15 ft. ¼ in. from rail to top of stack. The tractive force as a simple engine is 94,000 pounds, and as compound engine, 74,200 pounds. No. 840 is equipped with Duplex mechanical stokers. No. 780 is similar to No. 840 but weighs 4,000 more and has Street stokers.

On trip No. 1 from Hinton, W. Va., to Clifton Forge, Va., the heaviest train was hauled—3,623 gross tons—which is near the limit for the locomotive on the steeper grades. Two trips had maximum loads of 3,370 tons, and the other two trips carried 1,184 and 560 tons.

The gas analysis do not indicate excessive amounts of carbon monoxide which is the poisonous constituent of flue gases produced by incomplete combustion of carbon. The highest found was 0.16 per cent in the Millboro Tunnel during trip No. 3. This might be dangerous in half an hour should a train be delayed in the tunnel or happen to stall, but would have no noticeable effect during the two minutes duration of the usual passage. Another sample of the cab air was taken dring the trip through the Millboro tunnel, but the glass container was broken in shipment to the laboratory. Four gas samples taken in the Lewis tunnel during trip No. 5 gave 0.11, 0.08, 0.00, and 0.10 per cent carbon monoxide, an average of 0.07 per cent. Samples from four other tunnels gave 0.07 and 0.02 per cent, which is not important. It appears from the analysis that the gas hazard might become considerable in these tunnels only in case a train is delayed or stalled.

As a rule, the difficulty in breathing varies with the smoke, but this may not always follow when smoke is light and much irritating sulphur dioxide gas is evolved with the flue gas. Commercially manufactured pocket size respirators for smoke and gas were used when excessive irritation and difficult breathing were encountered. The worst condition was in the Millboro tunnel during trip No. 3, but the respirators entirely eliminated the irritation and difficulty in breathing. These respirators were of a type having low resistance to the passage of air, the resistance being one inch of water at an air-flow of 3 cu. ft. per minute (4 inches is considered a tolerable maximum in gas masks). Difficulty has been found in breathing through gas respirators of higher resistance when in hot atmospheres in tunnels of the Union Pacific Railroad, but no difficulty was experienced in breathing through the respirators with one inch resistance.

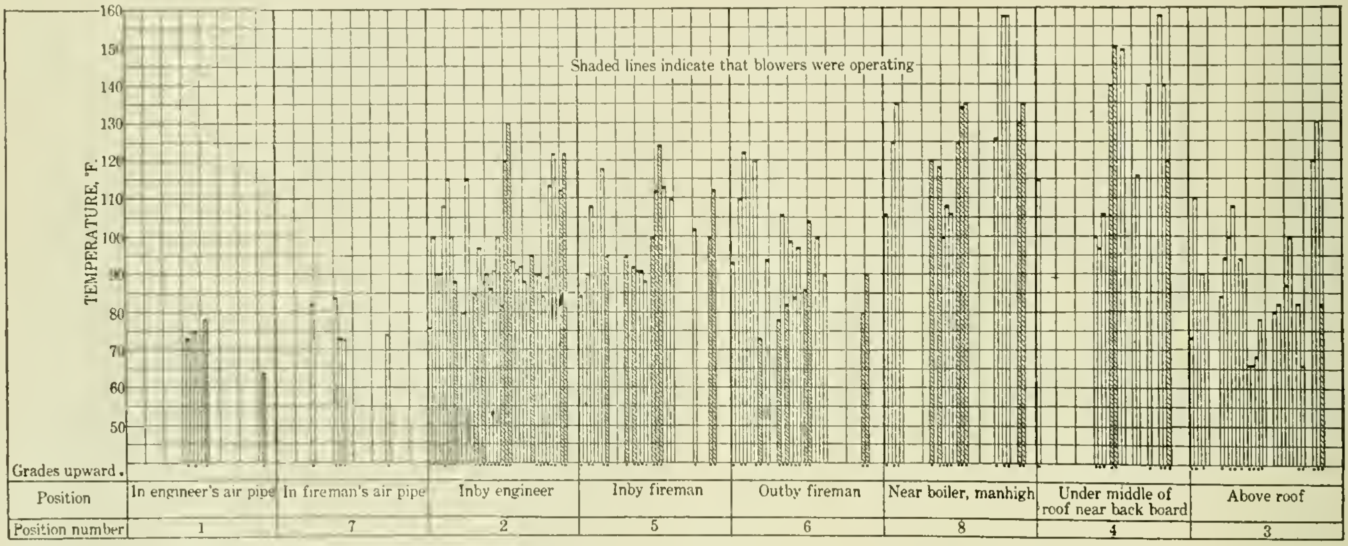
Temperatures in the Cabs

Especial attention was devoted to the determination of temperatures at different positions in the cab. Mercury or alcohol thermometers were used. The positions, specified exactly at the bottom of Tables 3 and 4, were taken to represent the temperatures as follows:

Position 1.—Air in the discharge pipe from the blower on engineman's side. 2.—Beside engineman, inner side. 3.—Above roof of cab. Thermometer was attached horizontally to an I shaped stick, weighted on the bottom, which hung on a catch at the rear edge of the roof; the horizontal stem was directed forward. It was taken down to read the temperature. 4.—Under middle of roof near backboard. 5.—Beside fireman, inner side. 6.—Beside fireman, next to window, nearly over blower pipe. 7.—Air in the discharge pipe from the blower, fireman's side. 8.—Near boiler, man high (say 6 feet) left of center. 9.—Outer surface of boiler lagging. This was determined by hanging a thermometer against the boiler and loosely covering the bulb with suspended waste. Temperatures were not read while in the tunnels. Outside of tunnels the temperatures varied from 170 to 193° F., usually dropping with the steam pressure.

With this system of fans, as installed on engine No. 840, the temperatures were not excessive at the locations of the men. The average at position No. 5 was 103° F., while at No. 6 it was only 94, this with a temperature in the blower pipes of about 76°. The highest temperatures were just beneath the roof in position No. 4, where it rose to 142°, and it is interesting to note that at this point it was hotter with the blowers in operation than when they were standing.

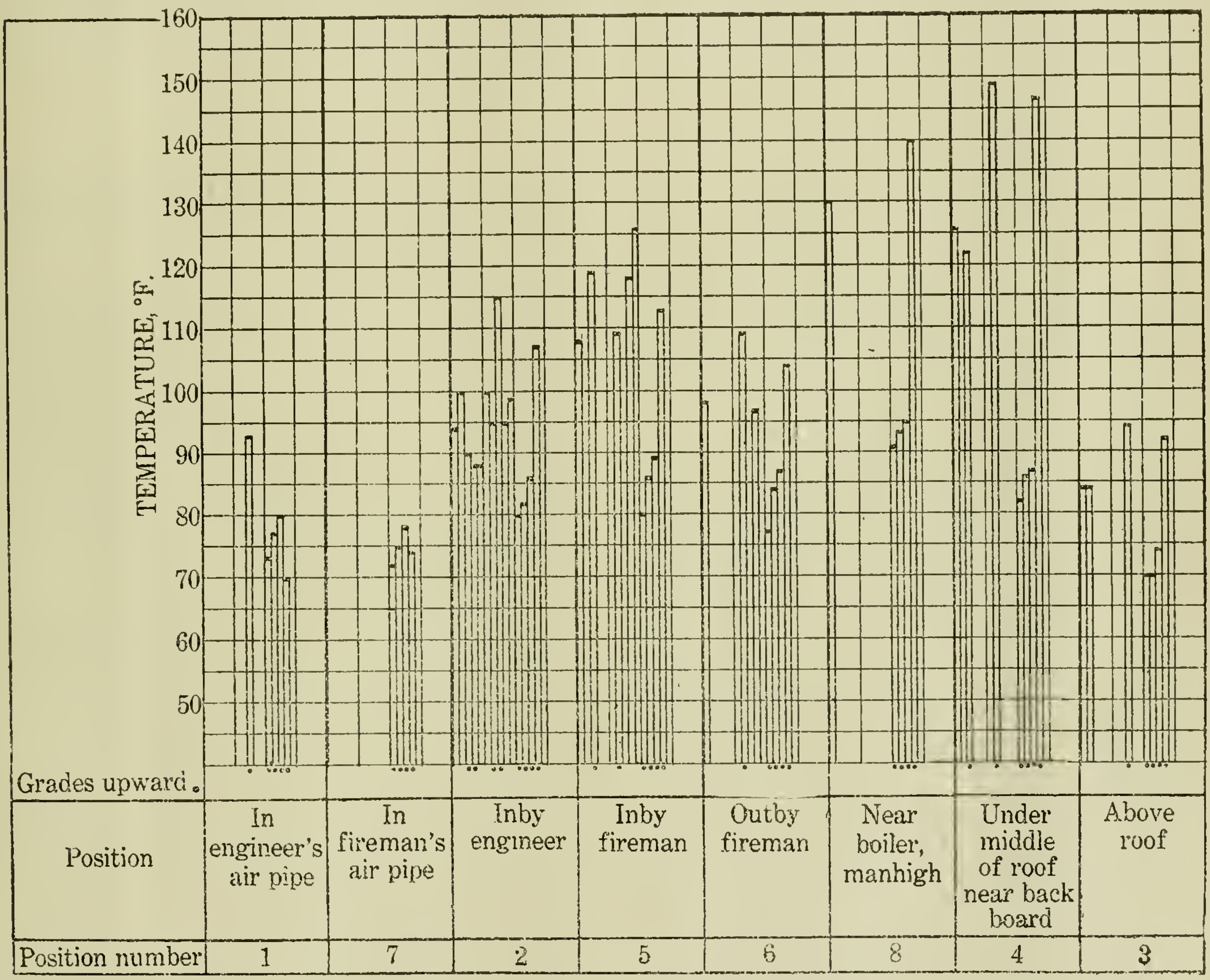
Wet and dry bulb temperatures to indicate the humidity were determined by a man facing the boiler and standing on the apron between the locomotive and tender, or in the center of cab and swinging a Bureau of Mines sling psychrometer. The highest temperature noted on the wet-bulb thermometer towards the end of the passage through the tunnels is recorded, but since 5 to 6 minutes



Temperatures in Locomotive Cab While in Tunnels of C. & O. Railroad During Trip West are needed for exact indications by wet-bulb thermometers even in a non-varying atmosphere, and the time was frequently shorter, the wet-bulb temperatures recorded are usually low. The dry-bulb thermometers were read following the wet bulb. Dry-bulb temperatures were not recorded in some instances, when difficulty in reading the wet-bulb thermometer consumed time after leaving the tunnels, during which the dry bulb changed.

Temperatures at positions 1 to 8 were observed soon after entering the tunnels allowing some time for thermometers to change. They were usually taken in serial order, sometimes reversing the order and sometimes omitting some positions. Records were made as rapidly as possible, and the round was repeated whenever time in the tunnel allowed. The temperatures indicated can be

All temperatures determined at each cab position are grouped together, each observation being placed according to the serial order of the round of observations, so that those made at one time occupy corresponding points on the graph. The figures show the wide differences at different times in any one position; however, they all show a general increase in the temperatures in the cab with the height above the floor. Contrary to expectation, no important differences in temperatures appear whether in tunnels, running outside of tunnels, or standing still. The highest average is 142 degrees at position 4, just under the cab roof, representing the temperature while in tunnels, with blowers operating. Temperatures at the positions near the engineman and fireman average about 100° F., whether in or out of tunnels. Since the physio-



Temperatures in Locomotive Cab While in Tunnels of C. & O. Railroad During Trip East

considered only approximations because of the lag of thermometers. Higher temperatures are usually indicated on each succeeding round. Vision was difficult because of the darkness, smoke, and sometimes considerable eye irritation. A flash-light was used, but it was frequently impossible to read the temperatures. For instance: In the Millboro tunnel on trip No. 3, after the first three observations no temperatures could be read, although repeated attempts were made.

The diagrams show graphically all the temperatures at each position in the cab for trips westward and eastward, respectively.

logical effects are not represented by the temperature alone, the decrease in comfort while in the tunnels must be due to the greatly increased humidity together with air movement; it has been determined that when temperatures of humid air exceed body temperature, any air motion increases the discomfort. It is unfortunate that more determination of wet-bulb temperatures were not secured. However, a few records show that sometimes the humidity is high enough to cause much discomfort.

Since the stack gases which enter the cab do not increase the temperatures to a noticeable extent, it would seem feasible to reduce the temperatures by increasing the boiler lagging. The smoke deflector, which causes the exhausts to stream backward over the cab without mixing with the tunnel air has been employed on a number of roads and has been found especially good.

Summary and Conclusions

The temperatures in the cab were found to increase with the height above the floor, the highest temperature of 158° F. being observed just under the middle of the roof of the cab.

Blowers were tried, these taking air from a point about two feet above the center of the track and introducing it through pipes, in streams directed upon the positions of the engine crew. The direct streams added some to their comfort, but the turbulence of the air in the cab was greatly increased so that the air impinged upon the boiler surface and became heated, with the result that outside of the direct streams no increase in comfort was felt, and sometimes the discomfort increased.

The temperatures of the mixture of exhaust gases and tunnel air above the roof of the cab were found much below those in the cab. High temperatures of exhaust gases entering the cab had previously been suspected of being the cause of the excessive heat felt, but this can not be true in the tunnels investigated. Rather the increased humidity of the cab air, while in the tunnels, due to the entrance of exhaust steam with the stack gases, seems to cause the discomfort.

Discomfort through heat may be lessened by increasing the lagging on the parts of the boiler exposed in the cab, and by means of the smoke deflector as used by the Union Pacific Railroad, which causes exhaust gases to stream backward over and away from the cab.

The tests described were undertaken through the arrangement of J. J. Ewing, engineer of tests for the C. & O. R. R., to whom the writers are greatly indebted.—Reports of Investigation, Department of the Interior, Bureau of Mines.

Abstract of Report of Interstate Commerce Commission on Power Brake Hearings

In our annual reports attention has been repeatedly called to the difficulties experienced in securing compliance with the requirements of law respecting the control of freight trains on grades by means of power brakes and the reports of our inspectors have indicated a lack of improvement in power-brake conditions commensurate with the requirements of safe and efficient operation.

It has been represented to us by certain carriers that freight trains can not be controlled with a proper degree of safety by means of power brakes alone upon grades on their lines, and that the use of hand brakes is necessary on such grades as an additional factor of safety. On the other hand, statements made to us by our own experts, as well as by qualified representatives of certain other carriers, express a contrary view.

The situation on the whole demanded a broad general inquiry by us into the subject of the use and operation of power brakes, and, we accordingly entered our order for this proceeding.

Practically all of the air-brake equipment in use was manufactured by the Westinghouse Air Brake Company and the New York Air Brake Company.

The devices around which most of the evidence centered in this investigation are, on the one hand, the triple valves of the Westinghouse Air Brake Company and the New York Air Brake Company, particularly those used in freight service, and, on the other hand, the triple valves of the Automatic Straight Air Brake Company.

There is a fundamental difference in principle of operation between the Automatic Straight Air Brake Company's triple valve and the triple valves of the Westinghouse and New York Air Brake Companies. The means of operation, however, are the same with all of these triple valves; that is, reduction of brake-pipe pressure causes an application of the brakes and increase of brake-pipe pressure releases the brakes.

The Westinghouse and New York triple valves when moved to application position by a reduction of brake-pipe pressure admit compressed air, which is stored in the auxiliary reservoir on the car, to the brake cylinder. When pressures in auxiliary reservoir and brake pipe equalize, the triple valve automatically moves to lap position and prevents further flow of air to brake cylinder, irrespective of the amount of pressure which may have been built up in the brake cylinder. A reduction of brake-pipe pressure or a number of successive reductions may be made until the pressures have equalized in auxiliary reservoir and brake cylinder; this is the maximum effect which can be obtained from a single service application of the brakes and constitutes a full-service application. When this condition has been reached it is necessary, in order to provide further braking power, first, to recharge the auxiliary reservoir, which requires the triple valve to be moved to release position, and, second, to make another application in the same manner.

The Automatic Straight Air Brake Company's triple valve when moved to application position by a reduction of brake-pipe pressure admits compressed air to the brake cylinder from the brake pipe and a brake-pipe reservoir. This triple valve moves to lap position to cut off the supply of air to brake cylinder when pressure in a predetermined ratio to the brake-pipe reduction has been built up in brake cylinder, irrespective of the volume required. When brake-cylinder pressure is reduced by leakage, the triple valve automatically returns to application position and compressed air again flows from brake pipe and brake-pipe reservoir to brake cylinder until brake-cylinder pressure is restored. With this triple valve the compressed air stored in the auxiliary reservoir is not used in making a service application except to serve as a constant pressure chamber at brake-pipe pressure for the purpose of governing the amount of brake-cylinder pressure which is obtained in each service brake application. This auxiliary reservoir pressure which is left undisturbed in service brake applications is utilized for two purposes, (1) in emergency applications it is admitted to brake cylinder for the purpose of obtaining higher brake-cylinder pressure than is obtained in service; (2) when releasing the brakes it is released to brake pipe for the purpose of causing a relatively rapid build-up of brake-pipe pressure and consequently a quick release of the brakes. This triple valve also provides for a so-called graduated release of brake-cylinder pressure, at a rate in proportion to the restoration of brake-pipe pressure.

Briefly, the Westinghouse and New York triple valves provide for the expansion of a fixed amount of compressed air into the variable volume of brake cylinder; the Automatic Straight Air Brake Company's triple valve provides for brake cylinder pressures of a fixed ratio to brake-pipe reduction, regardless of brake-cylinder volume.

It was the general view of the carriers that the present standard triple valves as used on freight trains meet the requirements of service adequately and efficiently when maintained in condition to function as they are designed to function.

Emergency applications on long freight trains at very low speed are considered objectionable because of the damage which frequently results. The carriers considered the attainment of emergency braking pressure after a substantial or full-service brake application unnecessary for long freight trains for the reason that the maximum speed of such trains is relatively low.

Emergency applications following shortly after release of service applications were also considered unnecessary.

It was stated the present standard brake equipment could be changed so as to provide for the attainment of emergency brake-cylinder pressure following a full service, application and also following release after full service, if that were considered desirable.

The carriers contended that it is not advisable to compensate for varying piston travel, because that travel should be maintained within the prescribed limits.

The Chicago, Rock Island & Pacific stated that operating conditions on its road with respect to brake equipment on freight trains are not entirely satisfactory. The maximum grades over which heavy-tonnage trains are operated are not in excess of 1.25 per cent, and therefore its operating men are not confronted with the difficulties of mountain grade operation; but while they endeavor to maintain brake equipment in normal condition, they are not able to obtain uniform braking with equipment now in use.

Troubles are frequently experienced on practically all roads in the operation of the present freight brakes, resulting from undesired emergency applications, brakes sticking and other causes.

The consensus of opinion of air brake officials who testified was that the present freight equipment with K-triple valves is adequate and in accordance with the re-requirements of safety when properly maintained. Several of these witnesses thought ability to obtain emergency following a service application would be a desirable feature, also that uniform brake cylinder pressure regardless of piston travel would be desirable.

Representatives of train service employees contended that greater reliability and flexibility in the operation of power brakes should be provided; that brake equipment should be maintained in better operating condition; that the use of hand brakes on grades should not be required or permitted; that undesired emergency applications should be eliminated; and that an emergency application should be available after a service application has been made and after release.

It was brought out in the testimony of enginemen and conductors that it is common practice to control the speed of long trains in level territory by use of the engine brakes alone and to use the automatic brake only to make a stop; that the use of the automatic brake to control the speed of long trains as experienced by these men would result in heavy slack action and shock, endangering employees on the rear end of the train, and that it is not considered safe to attempt to release the automatic brake on a long train running at low speed. They stated further that emergency is not used except when absolutely necessary, on account of the possibility of injuring employees, damaging equipment and lading, and buckling trains, and that undesired emergency applications occur with such frequency as to form a material factor affecting the safety of freight-train operation; in many cases these undesired emergency operations are attributed to lack of proper maintenance of brake equipment, but such operations also result from improper brake-valve manipulation. On one road it is the practice of enginemen when in level territory to operate with less than standard brake-pipe pressure so as to avoid undesired emergency applications. Enginemen testified that they commonly experience a feeling of apprehension or uneasiness when starting down a heavy grade until one or more application of the brakes have been made and they know definitely that the brakes are controlling the train. A number of enginemen testified that the present brakes when properly maintained are adequate to enable them successfully to control trains, but with poorly maintained equipment troubles increase, due to failure of brakes to apply or release as intended, undesired emergency applications, and difficulty in controlling trains on grades.

As for the Automatic Straight Air Brakes there are 100 cars equipped with them on the Norfolk & Western Railway, that have been run in association with the Westinghouse brakes and no trouble has been experienced in operating the two types of brakes in the same train. A demonstration and test of these brakes was made in 1921 and the train was successfully controlled and was operated without unusual slack action. A demonstration of a train of 34 cars equipped with these brakes was made on the Denver & Salt Lake Railroad in 1921, in which the train was successfully controlled on a descending grade of 4 per cent for 12.5 miles and 2 per cent for about 44 miles.

The Automatic Straight Air Brake Company appeared and presented evidence to show that the present power brake devices had certain defects and also evidence that set forth the development and service uses of the A. S. A. brake devices, and contended that a more general use of these devices would afford freedom from a number of the troubles now commonly encountered.

Other parties contended that the A. S. A. brake devices were still in an experimental stage, that the service tests to which they had been subjected had not been sufficiently extensive to warrant final conclusions.

After the hearing in this proceeding had been completed, in order to determine certain questions concerning which sharply conflicting evidence had been introduced, we reopened this proceeding for the purpose of a test by us of the brakes of the Automatic Straight Air Brake Company upon the Norfolk & Western Railway.

A proposed schedule of tests was submitted by the American Railway Association Committee and by the Westinghouse Air Brake Co. After a consideration of these recommendations a schedule was adopted.

The purpose of these tests was to determine and demonstrate the following specific questions:

A. Control of loaded train by means of automatic straight air-brake equipment.

B. Control of empty train by means of automatic straight air and Westinghouse brake equipment mixed.

C. Control of empty train by means of automatic straight air-brake equipment.

D. Effect upon operation of automatic straight air triple valves of long and short piston travel in different parts of same train.

E. Minimum brake application that can be made with automatic straight air-brake equipment with long piston travel.

F. Minimum brake application that can be made with automatic straight air-brake equipment with short piston travel.

G. Minimum brake application that can be made with automatic straight air-brake equipment with standard piston travel.

H. Effect of brake-cylinder leakage upon operation of automatic straight air-brake equipment.

I. Control of loaded train by means of automatic straight air and Westinghouse brake equipment mixed.

Different series of tests were conducted to demonstrate each of these questions.

In the report of the director of the Bureau of Safety covering these tests the conclusions which were reached are as follows:

1. The A. S. A. brakes as installed, maintained, and tested on the Norfolk & Western Railway are adequate for safely controlling both loaded and empty trains on that road.

2. When used in trains partly equipped with Westinghouse brakes, the A. S. A. brakes operated sufficiently in harmony with the Westinghouse brakes to effect the proper control of both loaded and empty trains.

3. When operated in graduated release, the A. S. A. brake provides an efficient means of controlling trains on grades.

4. With A. S. A. brakes absolute uniformity of brake-cylinder pressures was not obtained, but variation in brake-cylinder pressures was not excessive.

5. With A. S. A. brakes piston travel in a measure affects brake-pipe reductions and brake-cylinder pressures, but not sufficiently when maintained between operative limits to be a factor of importance.

6. When A. S. A. brakes have been applied by a light service reduction and brake-pipe pressure is further reduced by leakage and the operation of the A. S. A. triple valves, brake-cylinder pressures continue to increase until full-service brake-cylinder pressures are obtained, the time required being determined by the rate of brake-pipe pressure reduction.

7. With A. S. A. brakes emergency brake-cylinder pressures were obtained as desired in emergency tests including emergency application following service reductions and an emergency application following service and release; the availability of the emergency operation of the A. S. A. brakes immediately following a service application, or immediately following a service application and release of the brakes, is desirable as a means of increasing the safety of freight-train operation.

8. Abnormally high brake-cylinder leakage was created in standing tests to determine the ultimate limit within which it is possible to release the A. S. A. brakes. High brake-cylinder leakage results in relatively long periods of time being required to effect a release of A. S. A. brakes when in graduated-release position. On a standing 75-car train brake-cylinder leakage of approximately 17 pounds per minute on each car did not prevent the release of brakes after service reductions of 8 pounds and 20 pounds; brake-cylinder leakage on two cars near the rear of the train equivalent to the amount of air which could be supplied by the triple valves did not prevent release of the train brakes after service reduction of 8 pounds and 20 pounds; brake-cylinder leakage on three cars near the rear end of the train equivalent to the amount of air which could be supplied by the triple valves did prevent the release of the brakes on the rear end of a 75-car train after a 20-pound service reduction when all triple valves were in graduated-release position.

The report of the American Railway Association observers differs materially from the report of the director of the Bureau of Safety, and in order to formulate a decision in this case it is necessary to compose or to account for these differences.

The record clearly shows that the purposes of these tests were to determine whether or not the A. S. A. brake as installed on the Norfolk & Western Railway was safe and adequate for the control of trains and to establish definitely whether and to what extent certain desirable functions claimed for this brake were accomplished in service.

The report of the A. R. A. observers and the record in this proceeding indicate that the A. R. A. observers devoted their attention largely, if not wholly, to noting irregularities in the operation of the A. S. A. brake devices and based their conclusions largely upon a comparison of the results obtained under the prepared conditions created for test purposes, with the results that may be expected from the operation of standard brake equipment under normal conditions.

The Bureau of Safety report is based upon records automatically made by recording gauges and devices of the character recommended in the proposed schedule of tests submitted by the A. R. A. committee. On the other hand, the records upon which the A. R. A. report is based consist principally of notes, admittedly incomplete and fragmentary, made by the A. R. A. observers from their readings of dial gauges, which the record shows were often made under conditions rendering accuracy impossible.

The graduated release feature of the A. S. A. brake forms the basis of some of the principal claims made for this device. The Bureau of Safety report states:

3. When operated in graduated release, the A. S. A. brake provides an efficient means of controlling trains on grades and permits of relatively uniform rates of speed being maintained.

The A. R. A. report makes no specific mention of the operation of this brake in graduated release, but at the hearing representatives of the American Railway Association and the Norfolk & Western Railway testified that the A. S. A. loaded train was safely controlled on these grades and the functions of graduated release were successfully accomplished.

The A. R. A. report states that on the 50-car A. S. A. train trouble was experienced due to brakes failing to apply, failing to release, and to undesired releases. The Bureau of Safety report and the record in this proceeding show that this trouble was not sufficient to interfere with the proper operation of the train except in the instance cited in the A. R. A. report when brakes were sticking as the train started to leave the siding at Suffolk. At the hearing the fact was brought out that while on siding at Suffolk the stoker had filled the fire box with green coal, resulting in steam pressure not being maintained, which, in turn, caused brake-pipe pressure to reduce and the brakes to apply. The operation referred to therefore clearly was not due to any fault or defect of the brake apparatus or system.

Four emergency brake applications were made on the 50-car A. S. A. loaded train. The record shows that in all of these tests the train was stopped without damage and practically without shock. The time of serial operation of the brakes and the distances in which the train was stopped were longer than is considered desirable.

As a result of tests made with the 50-car A. S. A. train, the Bureau of Safety reports:

The A. S. A. brakes as installed, maintained, and tested on the Norfolk & Western Railway are adequate for safely controlling * * * loaded * * * trains on that road.

The record in this case substantiates that conclusion.

In respect to test made with the loaded train having equal numbers of cars equipped with Westinghouse and

A. S. A. brakes distributed in blocks of 5 or 10 throughout its length, the A. R. A. report states:

This test demonstrated that the A. S. A. brakes do not harmonize on grade work with present standard brakes. These latter did the greater part of the work of controlling the train as was indicated by the fact that the wheel temperatures on these cars were comparatively high, whereas the wheel temperatures on cars with A. S. A. brakes were low. No excessive temperatures were found.

From a tabulation of the wheel temperatures, as they were found, it appears that at the foot of Bluefield grade, of the 25 Westinghouse cars, temperatures of wheels on 21 cars were normal, on 2 cars the wheels were hot, and on 2 cars the wheels were cool. Of the 25 A. S. A. cars, temperatures of wheels on 19 cars were normal and on 6 cars the wheels were cool.

At the foot of Allegheny grade, of the 25 Westinghouse cars, temperatures of wheels on 18 cars were normal, on 6 cars the wheels were hot, the temperatures being excessive on two of the latter, and on 1 car the wheels were cool. Of the 25 A. S. A. cars, temperatures of wheels on 22 cars were normal, the wheels on the other 3 cars being hot.

The record therefore does not support the statements quoted above from the report of the A. R. A. observers.

The principal witness for the American Railway Association observers claimed that the reserve braking efficiency of the train was reduced because of the low brake cylinder pressure in the A. S. A. cylinders, during release periods. From tabulations of the trainograph records, it appears that the maximum brake-cylinder pressures were higher in the Westinghouse than in the A. S. A. cars. But it is questioned whether these variations in brake-cylinder pressure are in excess of those which frequently occur in common practice. In the sixth application on Bluefield grade the maximum brake-cylinder pressures ranged from 17 to 44 pounds, both extremes being recorded on Westinghouse cars in the forward portion of the train and having the same type of brake equipment.

Yet in spite of the alleged lack of harmony in the operation of the two types of brakes, this same witness acknowledged that the train was handled "in a very satisfactory manner."

The Bureau of Safety reports that throughout this run down the Bluefield and Allegheny grades the train was controlled practically without shock, and the record clearly establishes the fact that on this loaded train equipped partly with Westinghouse brakes and partly with A. S. A. brakes, the two types of brakes operated sufficiently in harmony to effect its proper control.

Tests were made with two trains of empty cars having a mixed brake equipment.

In the American Railway Association report the operation of the brakes on these trains was very severely criticized.

In these tests the purpose was to determine the operation which would occur under specified conditions rather than to demonstrate excellence of operation under favorable conditions.

The A. R. A. report states that "None of the emergency applications attempted went through to the rear of the train, but the partial emergency was transmitted to the seventy-fifth car in each case." The Bureau of Safety report on the other hand states that in all these tests emergency operation carried throughout the train; this latter statement is substantiated by the record, as shown by the testimony of one of the A. R. A. witnesses who examined the trainagraph records.

Criticism as to the slow serial operation of the A. S. A. brake is substantiated by the record. In the Bureau of Safety report it is stated, "The time of serial action of the A. S. A. brakes was longer than is considered desirable."

In regard to the standing tests the American Railway Association report states that they "confirmed what had already been demonstrated by the running tests, that with the A. S. A. brake equipment the minimum brake application which can be made is a full service application."

The record of either the running tests or the standing tests does not substantiate the statement.

The discrepancies are due to the fact that the tabulations of the Bureau of Safety are based upon trainagraph records made automatically, while the American Railway Association observers relied upon the reading of dial gauges at irregular intervals.

Additional reference may be made to a portion of one of the conclusions stated in the A. R. A. report, as follows:

The Automatic Straight Air Brake possesses no new features which are either desirable or practicable in general train operation.

The record establishes the fact that loaded trains were successfully controlled on descending grades by means of A. S. A. brake equipment operating in graduated release and without employing the short-cycle method, and warrants the conclusion that—

When operated in graduated release, the A. S. A. brake provides an efficient means of controlling trains on grades and permits of relatively uniform rates of speed being maintained.

Furthermore, emergency operations of A. S. A. brakes were obtained following a service reduction and following release after a service application.

In order that we might have the benefit of their views, the executive officials of several representative railroads were invited to and did appear at the hearing.

Mr. Kruttschnitt, chairman of the board of directors of the Southern Pacific Company, testified that as far as the Southern Pacific lines are concerned he believes there is no reason for making any change in the brake system now used; however, he does not believe that the railroads should get into the frame of mind of believing that nothing can be done to improve the present brake. In his opinion the tests were not of a conclusive nature.

President Mapother of the Louisville & Nashville Railroad testified that Westinghouse brake equipment has been and is satisfactory. As far as his road is concerned there is no particular advantage to be derived from an emergency application immediately following a full service application, and he considered the availability of emergency braking pressure following a release after full service not essential to safe and efficient operation of freight trains.

President Maher, of the Norfolk & Western Railway, testified that the experience on his road with the K-type Westinghouse air brake has demonstrated that while it is not 100 per cent perfect, it is a good brake.

President Jackson, of the Chicago & Eastern Illinois Railroad, testified that the experience of his road with the present brake, while the brake is not 100 per cent perfect, has been satisfactory and it is doing all that could reasonably be expected. If it were possible to obtain emergency operation following release of brakes after a full service application on freight trains, in his opinion, it would be desirable.

Mr. Freeman, receiver of the Denver & Salt Lake Railroad, testified that in 1921 his company equipped 40 gondola coal cars and three rotary snowplows with A. S. A. brakes. Since the tests in August, 1921, the cars equipped with A. S. A. brakes have been scattered around in the different trains and passed on in interchange to other railroads. No trouble has been called to his attention resulting from the A. S. A. brakes being mixed with the Westinghouse brakes. They have found the A. S. A. brake as used on their road adequate and safe to control the trains. If the brakes were obtainable his company would be inclined to equip 25 passenger cars immediately with A. S. A. brakes, and would also equip more freight cars, provided the difference in the cost between the A. S. A. and the Westinghouse brakes was within reasonable limits.

Vice President Galloway of the Baltimore & Ohio testified that in their experience it has been found that the present air-brake system in use on freight trains on their lines is satisfactory.

Throughout this proceeding the necessity for better maintenance of present power-brake equipment in order to secure proper operation and safely to contol trains was repeatedly stressed, and this necessity was recognized by both carriers and employees.

From the record in this case it appears that brake devices are available by means of which trains can be controlled on descending grades by simply increasing or decreasing the brake-cylinder pressure as required, without the necessity of releasing to recharge the train brake system. This function is clearly desirable; its general use would overcome the limitations of the present brake system in common use on freight trains.

A deficiency of the air-brake devices now in common use, as shown by the record, is that undesired emergency operations occur and are often attended by severe shocks which damage lading and equipment and endanger railroad employees. One of the common causes of such undesired emergency operations is erratic action of triple valves due to dirty or sticky valves, moisture in the system, or other similar condition. These operations are shown to be particularly dangerous and disastrous at low speeds, as it is at such speeds that the slack action and resulting shocks are greatest. More reliable control of the emergency operation of the brake system should be obtained.

Closely associated with this is the fact that with brake devices in common use emergency operation of the brakes can not be obtained immediately following a full service application, and that frequently neither an emergency operation nor an effective service application of the brakes can be had immediately following the release of the brakes after a service application.

The conclusions reached are those published in the August issue of Railway & Locomotive Engineering.

Commissioner McManamy's Dissenting Report

Commissioner McManamy submitted an opinion dissenting in part from the report as follows:

"The conclusions of the majority in this case are directed towards the accomplishment of two definite purposes, (*a*) better maintenance of existing power-brake systems, and (*b*) fundamental changes in the design of power-brake systems to make possible additional functions.

"I am in full accord with the conclusion requiring better maintenance. The evidence abundantly shows the need for better maintenance of power-brake systems and the improved performance which will result therefrom. No witness, either for carriers, the brake manufacturers, or the employees, testified that power-brake systems as a whole were maintained in an efficient or satisfactory operating condition. On the contrary, every witness testified that improved performance would result from better maintenance and that such better maintenance should be required. I am not in agreement, however, with the conclusions which require changes in the design of power-brake systems in order to make possible the performance of additional functions not now included in existing standard freight brakes, because (1) the record does not show that the existing power-brake systems if properly maintained are inadequate to safely control trains; (2) if existing brake systems are adequate, I question our authority to require the use of improved devices; and (3) the investigations and tests are insufficient, to my mind, to definitely show that the proposed changes in design can be made without introducing undesirable features which will offset any benefits which may be derived therefrom.

"In my opinion the basic question presented in this proceeding is: When properly maintained are existing power-brake systems adequate to safely control trains under present operating conditions? If we find in the affirmative, we should prescribe and enforce standards of maintenance that will insure proper performance and maximum efficiency of existing power-brake systems. In my opinion it has not been shown that present brake systems are inadequate; therefore a further question arises. If existing systems are adequate to safely and efficiently control trains, and if improved devices are available which are not being used, have we authority, in addition to requiring better maintenance of the power-brake systems in use, to also prescribe specifications and requirements which will compel the use of such improved devices? I question that section 26 of the act, under which this proceeding is brought, gives us such authority.

"The outstanding feature of this case, to my mind, is the fact that the record is barren of evidence that the existing power-brake systems, when properly maintained, are inadequate to safely and efficiently control trains under present-day operating conditions. This statement is supported by the majority report.

"Efforts to improve power-brake systems should, without doubt, be diligently continued, and where it can be definitely shown that improvements in design have been made which would increase the safety of operation, such improvements should be incorporated in the existing power-brake systems. But, to my mind, the evidence in this case has fallen short of showing that improvements are available which do not, at the same time, possess undesirable features sufficient to counteract the good effects hoped for, thus leaving no net gain.

While the conclusions of the majority are stated in general terms and without reference to any particular type of brake, the report throughout is based upon a comparative test of the automatic straight air brake, in which all of the features recommended are said to be incorporated, and the Westinghouse brake, the one in general use. The additional features are not used on the latter, because they are said to be undesirable. It is unfair to select specific brake applications and attempt to base a conclusion thereon as to the relative merit of different power-brake systems. This was the principal cause for the disagreement between observers at the Norfolk & Western tests.

"Viewing the situation in its broadest light, the present power-brake system has been in general use for more than half a century and from time to time changes and improvements have been made. It is in service on 2,500,000 cars and locomotives. The uncontradicted testimony of carriers' witnesses is that when properly maintained it safely and efficiently performs the required functions. This testimony is from representatives of railroads that are safely and satisfactorily controlling by means of power brakes heavy passenger and freight trains on the steepest mountain grades in the country. In view of this testimony we can not find that standard power-brake systems, properly maintained, do not meet every requirement of the law. On the other hand, the record shows that the other brake system has placed in service during the past few years only 199 brakes on four different railroads.

Of these, 140 are on freight and 59 on passenger cars. The only information available respecting the performance of these brakes has been developed during the past two or three years and, in so far as the emergency features are concernd, is limited almost entirely to that resulting from the Norfolk & Western and Virginian tests. To my mind these tests alone are insufficient to form the basis of an order directing fundamental changes in the design of power-brake systems. If, based on these tests, we find that certain additional functions, such as emergency following release, emergency following service, or the ability to graduate brakes on or off can be performed, we must at the same time give consideration to the undesirable performances, which admittedly occurred during these tests, resulting from the changes in design. Among these are the effect of leakage variation in piston travel and the slowing up of serial action which are referred to in the report.

"Quick serial action of brakes required 30 years to develop to a point where it is possible to obtain satisfactory brake performance on 100-car freight trains. Briefly, it means that the action of the brakes throughout the train must be quicker than the action of the slack in the train. That is, the brake on each car must respond so quickly that each car will be stopped by its own brake and not by striking the car ahead. The tests show that substantially more time was required to apply the A. S. A. brakes on 100-car trains than to apply the standard brakes. This necessarily results in greater shocks and in greater damage. To my mind, the ability to make smooth stops is more important in freight-train braking than the ability to make quicker stops, and the testimony is uncontradicted that the shocks resulting from the emergency application of the A. S. A. brakes on the test trains were severe. The testimony is conflicting as to whether or not the shocks were more severe than on similar trains equipped with standard brakes, and no tests were made to determine this point.

"If the additional features to be incorporated will increase the severity of the shocks on long freight trains, which are at present a serious source of danger to train crews, it may well be that freight-train braking would be safer and more satisfactory without such feature. It is well recognized that greater property damage and more personal injuries result from rough freight-train stops than from failure to get emergency action following release or following service.

"The additional increased safety in mountain braking which comes from the additional supply of air carried on each vehicle with the A. S. A. brake is a factor which may well be given consideration, but the performance of the test trains did not afford opportunities for demonstrating what value this would be in an emergency.

"For the above reasons I can not join with the majority in the conclusion that we should order fundamental changes in brake designs as stated in their report, without further evidence (1) of the need for such additional features and (2) of the possibility of their satisfactory performance. I believe, however, that further trial of these changes in design should be encouraged in every proper way.

"I am authorized to state that Commissioners Eastman and Potter join in this expression.

Swiss Railway Electrification Progresses

Switzerland's progress in the electrification of the Federal Railways is illustrated by the completion of the electrification work on the line from Chiasso at the Italian frontier to Basel at the German-French frontiers. The last section of this line, from Olten to Basel, was formally opened to electric traction on June 1, 1924, thereby completing a continued stretch of railway line with electric traction, crossing the entire country and having a total length of 315 kilometers or 197½ miles. The completion of this line brings the total electrified trackage to 504 kilometers (315 miles) including the Simplon tunnel line from Brigue to Iselle, 22 kilometers long, which was opened in 1906.

The program of electrification of the Federal Railways in Switzerland is a result of the severe economic conditions which existed during the war, when the Swiss people were dependent on foreign countries for coal and were forced to purchase it at extremely high prices. The necessity of procuring this necessary element for steam traction led to the consideration of finding a method of securing the economic independence of the country by providing a motive power which would be self-sustaining and independent of foreign assistance during times of emergency. This situation led to the adoption of a plan of electrification of all the important lines in Switzerland by the General Direction of the Swiss Federal Railways. Before the war, the importation of coal for the Swiss Federal Railways amounted to an average of 700,000 tons. During the year 1923 the expenditures for coal amounted to 28,214,000 Swiss francs (1 Swiss franc equals $0.192 normal exchange) for a total distance of 29,063,449 kilometers traveled by steam traction, showing an average price of 97 centimes per kilometer for the cost of fuel in steam traction during the year 1923. A comparison of the cost of electric traction during the year 1923 with steam traction shows that in that period 7,667,000 Swiss francs were expended for electric power for a total distance traveled of 5,956,850 kilometers by electric traction. This gives an average cost of electric traction to 1.28 francs per kilometer in comparison with 97 centimes per kilometer for steam traction during the last calender year.

The electric energy for the operation of the Chiasso-Basel line is furnished by two power plants at Ritom and Amsteg, aided by the Goeschenen plant at the northern entrance to the Gotthard tunnel. Both plants can deliver throughout the year an average of 32,000 horsepower and it is expected with the completion of the full installation in the Ritom plant that 72,000 horsepower will be developed.

The express trains are drawn by electric locomotives weighing 112 tons and having a total length of 52 feet. These electric locomotives are capable on the maximum gradient of the Gotthard line, of a speed of 50 kilometers an hour with a 300-ton train and are constructed to furnish an average speed of 75 kilometers an hour, rising to 90 kilometers an hour in the valleys and on level ground. The last steam locomotives constructed for express trains in 1908 furnished a speed of 35 kilometers an hour with a train weighing 190 tons on the maximum gradient. These last steam locomotives purchased, cost 146,000 Swiss francs each, while the new electric locomotives were purchased at an average price of 800,000 Swiss francs each. The electric locomotives designed for freight service have a maximum speed of 65 kilometers per hour and weigh 128 tons.

Running Longer Freight Trains This Year

A report just issued by the Bureau of Railway Economics based on Interstate Commerce Commission figures show that in the first six months of this year the average number of freight cars per train was 40.7 compared with 38.9 the first six months of last year.

The gross tons per train—exclusive of the locomotive and tender—in the first six months of this year was 1,542 compared with 1,507 a year ago.

Fuel Economy Campaign—Yielding Results

By W. E. SYMONS

Success usually comes to him who waits, provided he persistently, intelligently and honestly strive for the end in view, while waiting.

Rewards should not and seldom do come to the idler, or visionary theorist. For the past 30 years or more economy in fuel has been preached by many, and several different methods of attacking the problem were offered that pointed the way to great saving. Not a few of these suggestions have been acted upon with good results, although the general movement in fuel economy on our railways may be properly stated as of more recent date.

The attitude of most all those who have to do with economy in railway operation has for some time been focused on the fuel question, with the result that if there were any laggards they have either experienced a change of heart, or at least pretend to have undergone such change and are shouting fuel economy.

At the annual meeting of the International Railway Fuel Association convention in May, 1924, Mr. Aishton, President of the American Railway Association, gave a most striking example of what great combined results might be obtained as the result of each officer and employee saving just one pound of coal per unit of service, holding in his hand a small lump of coal weighing one pound, such as we often throw at a strange dog or cat, and explained that by saving just one pound of coal to each 1,000 ton miles, passenger car miles and switching, the money saving at the end of the year would be about $3,165,000.

The general activity in this matter during the past few years throughout the railway field is already bearing fruit as shown by reports of the Interstate Commerce Commission, and it is confidently hoped that much greater improvements may be shown in the not far distant future.

Big Improvement Over 1922

In our March issue we presented a tabulated list of some 22 columns of statistical data of selected items pertaining to operating results of forty (40) railways.

In the matter of fuel consumed the figures were as follows:

Pounds of coal per 1,000 gross ton miles, lowest, 76 lbs.; highest, 238 lbs.; average, 179 lbs.

W. E. Symons. Aug. 1924.

	Name of Railway	Mileage and Engines on Line Daily		Gross Tons Per Train		Aver. Frt. Car Miles Per Day		Aver. Pass. Eng. Miles Per Day		Aver. Frt. Eng. Miles Per Day		Pounds Coal Per Pass. Car Mile		Lbs. Coal Per 1000 Grs Ton Miles		Per Cent Saving Pass. & Frt.	
		Mileage	Engines	1923	1924	1923	1924	1923	1924	1923	1924	1923	1924	1923	1924	Pass.	Frt.
1	At. Coast Line	4,860	446	1,267	1,297	31.1	31.3	86.9	86.1	61.8	59.4	15.0	13.5	125	120	10%	04%
2	A. T. & S. F.	9,722	932	1,495	1,657	31.4	27.8	127.2	121.3	65.3	55.0	15.5	13.8	147	121	10%	17%
3	B. & O.	5,212	1,314	1,711	1,722	29.4	23.0	148.9	134.5	69.1	52.3	17.1	16.1	170	161	06%	06%
4	Big Four	2,379	436	1,971	1,897	33.3	29.1	132.3	139.6	55.7	49.7	14.7	13.5	120	117	06%	
5	Boston & Maine	2,286	462	1,146	1,186	18.7	18.6	75.4	72.0	54.8	43.9	19.5	17.9	166	148	11%	07%
6	Cent. of N. J.	694	278	1,065	1,041	13.8	12.5	82.8	79.4	43.7	39.8	27.9	28.7	179	172		
7	Chicago & Alton	1,050	156	1,451	1,428	26.5	24.3	110.5	111.4	67.7	62.9	17.7	18.0	135	135		
8	C.M. & S.S.M.	4,374	343	1,216	1,285	22.8	21.3	112.5	111.5	53.3	47.6	12.2	12.0	109	110		
9	C. M. & S. P.	11,025	1,103	1,433	1,571	28.1	24.8	103.4	105.1	57.4	42.8	17.3	16.0	138	138	06%	
10	C. B. & Q.	9,393	1,015	1,596	1,624	31.8	26.2	121.7	117.1	57.7	45.7	16.2	14.1	157	148	12%	05%
11	C. & N. W.	8,403	1,063	1,314	1,320	24.9	22.8	110.7	105.8	50.4	44.6	18.6	18.1	143	143		
12	C. R. I. & P.	7,635	776	1,185	1,289	32.2	31.2	106.0	105.3	65.2	63.6	18.4	17.6	168	150	06%	10%
13	C. & O.	2,550	535	2,386	2,393	32.8	42.2	104.9	111.5	61.6	66.6	17.6	17.6	115	112		04%
14	Del. & Hud.	886	288	1,771	1,694	31.2	31.0	85.2	72.2	72.0	60.2	22.6	20.4	187	174	09%	05%
15	D. L. & W.	953	364	1,747	1,760	33.3	29.8	113.8	104.9	71.4	60.7	19.7	19.3	187	156		10%
16	D. & R. G.	2,604	329	1,251	1,433	16.6	13.9	81.6	94.5	36.3	28.6	18.4	16.9	226	195	08%	13%
17	Erie	2,438	755	2,120	2,160	32.1	24.7	89.2	93.2	49.3	46.3	16.4	15.2	125	119	06%	04%
18	Frisco	4,633	491	1,072	1,200	25.0	26.4	132.8	126.5	58.3	55.6	17.6	14.6	180	156	20%	12%
19	Great Nor.	8,255	754	1,967	2,169	26.8	23.6	101.6	92.9	42.0	33.4	15.6	14.3	124	116	06%	06%
20	Ill. Cent.	6.164	900	1,684	1,716	41.5	37.0	124.9	117.5	81.4	63.3	18.3	18.0	132	123		06%
21	Lehigh Val.	1,335	550	1,737	1,736	23.1	25.1	82.7	88.4	45.9	41.4	16.5	16.1	164	146		11%
22	L. & N.	5,036	717	1,158	1,164	29.5	26.7	142.0	142.8	88.6	82.6	19.6	19.4	166	155		06%
23	Mich. Cent.	1,862	354	1,754	1,773	30.5	28.0	133.7	135.8	50.1	50.7	11.9	11.3	114	114		
24	Mo. Pac.	7,148	623	1,391	1,492	29.1	30.7	116.9	131.0	62.1	59.8	18.6	15.4	153	132	12%	13%
25	N. Y. C.	6,899	1,653	2,193	2,135	28.5	23.7	133.7	135.8	55.4	42.6	12.6	12.1	115	111		03%
26	N.Y.C. & S.L.	1,242	313	1,499	1,621	48.8	39.1	137.3	157.4	81.7	63.7	16.4	16.1	124	113		09%
27	New Haven	2,000	369	1,258	1,356	14.2	15.0	93.0	89.1	54.8	43.9	18.7	16.8	160	132	10%	17%
28	Nor. & West.	2,237	680	2,272	2,351	34.5	34.0	96.2	111.7	53.4	47.4	25.3	22.4	173	154	11%	11%
29	Nor. Pac.	6,631	722	1,654	1,624	28.8	23.0	92.3	87.1	45.3	35.8	14.4	12.3	125	118	10%	06%
30	O. S. L.	2,374	217	1,420	1,460	34.4	29.4	110.5	120.5	53.0	46.0	12.9	12.6	136	140		3%
31	Penn. System	10,534	3,519	1,804	1,766	25.8	19.7	119.2	115.0	61.6	45.3	17.9	16.8	138	136	06%	07%
32	Pere Marq.	2,227	210	1,442	1,387	19.1	22.2	102.7	94.3	63.5	57.0	15.9	15.4	122	119		03%
33	Phil. & Read.	1,125	492	1,686	1,623	23.2	20.5	79.5	76.2	61.7	46.8	27.0	26.5	168	166	06%	
34	Pitts. & L.E.	231	88	2,742	2,574	15.0	7.9	91.3	97.9	72.2	40.7	24.2	28.5	72	69		04%
35	So. Pac. P. S.	7,116	837	1,741	1,873	44.3	40.3	139.0	131.3	80.9	67.2	12.3	11.3	138	122	06%	10%
36	Southern Ry.	6,971	977	1,180	1,248	28.7	26.2	111.5	105.2	58.8	46.9	19.0	18.0	190	165	06%	13%
37	Tex. & Pac.	1,952	200	1,258	1,305	26.3	30.1	109.0	123.6	37.7	45.8	14.5	13.1	138	129	06%	06%
38	Union Pacific	3,708	512	1,771	1,926	49.6	44.6	147.6	152.1	64.6	51.1	12.8	12.2	140	123		10%
39	Wabash	2,472	357	1,568	1,734	39.0	37.3	144.5	141.3	63.2	54.6	15.2	15.9	138	135		
40	Sou. Pac. A.S.	3,710	285	1,265	1,303	31.4	29.8	151.9	156.0	68.6	73.0	12.3	11.0	122	113	10%	07%
	Totals & Averages For United States	172,376	26,415	1,591	1,632	29.1	26.8	112.1	112.2	59.9	51.6	17.6	16.0	145	134	08.5%	08%

Statistical Data of 40 Railways With Comparison of Selected Items of Operating Expenses for the Months of June, 1923, and June, 1924

Passenger—Pounds of coal per passenger car mile, lowest, 13 lbs.; highest, 30.6 lbs.; average, 20.4 lbs.

The wide range in the amount used by the different roads is not, of course, a measure of efficiency in operation as it also reflects physical characteristics of the line and also service conditions. These figures do serve, however, to point out clearly the opportunity to effect great economies on certain lines, and through special methods on all lines.

The I. C. C. reports for the month of June, 1923, and June, 1924, on forty railways shows the following quantities of fuel consumed per 1,000 ton and passenger car miles:

June 24—Pounds of coal per 1,000 gross ton miles, lowest, 69 lbs.; highest, 195 lbs.; average, 134 lbs.

Passenger, (June, 1924)—Pounds of coal per passenber car mile, lowest, 11 lbs.; highest, 28.7 lbs.; average, 16.0 lbs.

These averages, based on a comparison of the full year of 1922 on 40 railways, and the month of June only on 40 railways show a decrease of 25 per cent in freight and 20 per cent in passenger, but as it would be manifestly unfair to compare the month of June with an entire year which include the winter months with extra demands for fuel, we will make comparison of the months of June, 1923 and 1924, which are as follows:

Period	Average lbs. coal per pass. car mile	Average lbs. coal per 1,000 gross ton miles
June, 1923	17.6	145
June, 1924	16.0	134
Per cent saving	.09%	.075%

This comparison of two summer months in which the climatic conditions are favorable to the minimum fuel consumption not only shows a substantial improvement in twelve months, but the following tabulation of the 40 lines gives other information pertaining to the economy in operation and to which attention is invited.

Past, Present and Future

The railways have during the past 25 years paid out for fuel more than SEVEN BILLION DOLLARS.

The fuel bill last year was........$617,800,000
This is at the rate of about.........$1,692,603 per day

The future supply of coal is variously estimated at from 546 years to as high as 1,500 to 2,000 years. The supply of crude oil is estimated at about 20 years. There is enough shale oil in shale rock in the state of Colorado alone to keep 100 crushing and distilling plants with capacity of 2,000 tons of shale rock per day, busy for "800 years."

The potential capacity of hydro-electric power is almost unknown, but none of the foregoing is even a mitigating feature with respect to the great waste in railway fuel that *can* and *should be saved*.

What are you doing? Not talking about, but actually doing in this matter. It has recently been clearly pointed out where and how savings of $3,165,000 to more than $26,000,000 can be effected and at the same time materially increase the efficiency of engines. It has been estimated that the combined possible saving in fuel for our railways might be as high as $70,000,000.

Are you saving at the *Spigot*, and losing at the *Bung Hole*.

When Alexander the Great sat down and wept that there were no more worlds to conquer, he had only scratched a little around the edges of the habitations of man, but had allowed himself to believe the job was finished, when as a matter of fact it was only well started.

If there be any (and we suspect there are quite a few) who think of this fuel problem as Alexander did of his achievements, then they will eventually experience a rather rude and most unpleasant awakening.

Staten Island Railway to Electrify

Electrification of approximately 17 miles of double track passenger line of the Staten Island Rapid Transit Company and the Staten Island Railway Company is now under way, an order having recently been placed with the General Electric Company for eighty 2-motor equipments.

The motor equipments will be installed on subway type of steel coaches seating 71 passengers. Each coach is separately driven with two motors of 200 horsepower each, operating at 600 volts and equipped with G. E. type PC-10 control.

Trains from two to ten cars can be operated from one controller with a maximum speed of approximately fifty miles per hour. Current to the trains will be supplied through a top contact third rail.

The cars, which are to be manufactured by the Standard Steel Car Company, will be similar to those now operating in the subways of the Brooklyn Manhattan Transit Corporation. Before going into operation the completed cars will be tested on the test tracks of the General Electric Company at their Erie Works in Pennsylvania.

The Staten Island Rapid Transit Railway Company operates between St. George and South Beach and the Staten Island Railway between Clifton Junction and Tottenville. These lines are a part of the Baltimore and Ohio system.

Safety Campaigns Among Railway Employes Progress

Last year reportable casualties on the Union Pacific amounted to 1.36 per 100 employes, compared with 7.72 per 100 employes in 1915.

Last year on the Southern Pacific at its repair shops at El Paso, Texas, employing about 1,000 men, there was but one single reportable accident in seven months. The company shops at Algiers, La., reported only three injuries in a period of six months.

According to figures compiled by the Committee on Statistics of the Safety Section of the American Railway Association, 2,550 employes were killed on the railroads in 1900. In 1923 this figure had been reduced to 1,866 in spite of an increase of approximately 46 per cent in the number of employes.

The number of injuries in this same period, however, increased from 39,643 to 148,146. Many of these are regarded as being of minor importance. According to Mr. Carl Gray, President of The Union Pacific, this only emphasizes the importance of safety work and safety campaigns. In addressing the Safety Section of the American Railway Association at its Fourth Annual Meeting at Salt Lake City recently, he said:

"The foundation work of a safety organization is of paramount importance. The work will not flourish under haphazard or catch-as-catch-can methods.

"At the beginning some very definite ideas and aims must be shaped into a program and the officers and men must be fully advised of the endeavor as well as be impressed with its importance.

"Distinction is made between the officers and men for the reason that we recognize the fact that these employes, commonly referred to as 'the men' in a large degree follow the example set by their officers, and the degree of interest which will be displayed in the work by the men who are our real safety evangelists will be determined by the interest which is evinced by their officers."

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Tunnels, Their Gases and Temperatures

In another column an abstract of a report of the Bureau of Mines will be found that deals with an investigation as to the temperatures and gases found in certain tunnels of the Chesapeake & Ohio R. R. The engine principally used was equipped with a fan blower taking air from a point near the rails and blowing it into the cab in front of the seats of the engineer and fireman.

In the November, 1920, issue of RAILWAY & LOCOMOTIVE ENGINEERING there was an article descriptive of a duct for conveying the smoke and gases from the stack to a point of discharge back of the hood of the cab, and a method of ventilation similar to that set forth in the report under consideration. These were in use on that portion of the Southern Ry. between Cincinnati and Chattanooga. And again in the March, 1923, issue, there was a description of a tunnel mask used on the same lines.

The tunnels on that road between Danville, Ky., and Oakvale, Tenn., are single tracked and with barely clearance enough for the engines. Indeed so completely are they filled that it is impossible to get off one of the large engines when they are in the tunnel. And when passing through the temperature in the cabs rise to a point where one's clothing seems to be on fire and the exposed skin of the body to be blistering. But under ordinary conditions even such as these it is not the high temperature that causes the maximum of distress but the quality of the air that one is forced to breathe. Without the method of ventilation, the usual custom of burying the nose and mouth in a handful of waste affords some relief, but it frequently requires the exertion of great will power to refrain from removing the waste for an imaginary gasp of air.

The high temperatures registered under the roof of the cab do not exist at the breathing level, so that air quality is what should be provided, with some disregard of temperature.

This can be secured by the use of a suitably constructed tunnel mask taking air from the main reservoir of the air brake system. The air drawn from that source has already been filtered and the heat of compression has been radiated so that, as it expands in the tunnel mask, it is cooled well below that of even the outside temperature and breathing can be conducted as freely and comfortably as outside, while the discomforts of the high temperature are hardly worth considering.

For a hand-fired locomotive, and where coal has to be placed in the firebox while traversing a tunnel the mask possesses the inconvenience of having a tube connection to the air brake system, and this is hampering to the movements of the fireman. But, with a stoker-fired engine, the mask sets up conditions of comfort so far as breathing is concerned.

The fan blower, such as that described delivers a stream of fresh air to the two men of the crew and if they choose to bend forward and let it blow in their faces, there is no reason why they should be in difficulty.

The same conditions prevail where the Churchill system of ventilation is used. When the train is running with the blast, it runs slowly and its exhaust steam and gasses are carried on ahead of it, leaving the atmosphere of the cab clear and of a temperature only slightly above that of the outside air.

This was demonstrated in the case of the tunnels fitted with the Churchill ventilators in the Bureau of Mines investigations, where the temperature was as low as from 82° to 87° in the fireman's side, and the notes say that there was no discomfort, no smoke, moisture heavily condensed and fans delivered good cool air. And in one case the notation is that, before entering such a tunnel, the temperatures ranged from 97° to 131°, yet while in the tunnel the temperatures on the two sides of the engineer were 70° and 107°, respectively and on the two sides of the fireman's seat they were 113° and 104°, respectively.

It is apparent, then, that with appliances that are available, it is possible to make tunnel work not only safe as far as gases are concerned but reasonably comfortable in the matter of temperature.

The Churchill system is expensive to install but the tunnel mask will afford every protection that is really needed. It is inexpensive in first cost, and the connections for using it can be readily applied on any locomotive. So that it would seem that, in any trouble from tunnel gases, the responsibility rests either with the management for failing to provide the necessary means of relief, or on the men for failing to make use of the means provided, which frequently happens to be the case.

Designing for Repairs

The outside drypipe placed upon the Mallet locomotives of the Kansas City Southern Ry., as illustrated in another column of this issue, offers a solution of some of the troubles experienced with the inside pipe as ordinarily applied. It must be frankly acknowledged that it does not improve the appearance of the locomotive, and it may be difficult to make such an application on some locomotives. In many instances the boiler shell has so large a diameter that the clearance space above it limits the dome to the size of a mere wart, and cuts the outside stack down to not much more than a ferrule around a hole in the smokebox. Under these conditions the placing of an 8½ in. or 9 in. pipe with the necessary flanges that will bring the diameter required up to 16 in. may be out of the question, and then there does not seem to be any course open to the designer but to place the dry-pipe in the conventional position inside of the shell.

But the principle that led to the use of this form of pipe on the Kansas City Southern of designing for the repairman is one that every designer should keep constantly in mind.

Any part of a locomotive is apt to fail at any time, and a failure of some parts may so delay the machine at the terminals because of inaccessibility, as to prevent it from going out on its regular run. Everything about the modern locomotive has become so heavy that what were once simple repairs quickly made, now take a great deal of time and cost much because of the weights to be handled, and if inaccessibility is added to the weight the difficulties and expense may be much more than doubled.

Main rods, for example, that once upon a time could be taken down for the filing of brasses, by one man, must now be handled by jacks or cranes and even the brasses themselves are too large and heavy to be picked up and carried about. And this leads to a reminder, if any reminding is necessary, of the desirability of cutting down weights by the use of especially selected material. But in regard to this one is hardly called upon to read a lecture, for that has been pretty constantly preached for the past two decades. Still there is probably some room for improvement. This would seem to be especially true of the reciprocating parts. When we read of such parts weighing more than a ton, and see the counterbalance in the main driving wheel filling the whole or nearly the whole of the half circle opposite the crank pin, we know that the limits have been reached and that there is at least a field for study open to the designer.

It goes without saying that an increase of accessibility will be accompanied by a decrease in the cost of repairs.

And, by the way, would it not be well, sometimes, to base the cost of repairs on weight simply for the sake of obtaining comparison?

The old standard locomotives that had a total weight in working order of from 80,000 to 90,000 lbs. ran over tracks that were far inferior in smoothness of alinement to those obtaining today. Yet their repair costs were far less per mile, but they weighed less and hauled less. A train of fourteen cars with a total weight behind the tender of not more than 280 tons was a very heavy train. If we compare this engine's weight and its performance with one of the present day we can easily multiply its weight by four or five and its tonnage rating by eight or ten which would be a fairer basis of comparison of repair costs than that of mileage.

But in spite of this favorable showing we are and ever shall be confronted with the demand for an increase of efficiency and decrease of cost and there is probably no better way to accomplish both of these objects than for the designer to add accessibility to the object that he has in view.

The Report on the Power Brake Hearing

The report on the Power Brake Hearing before the Interstate Commerce Commission, the conclusions of which were published in the August issue of Railway and Locomotive Engineering, and which is now given more in detail, in another column, is deserving of the close attention of all who are interested in brake application.

There was so much of contradictory evidence at the hearings as to the functioning of all brakes that the commission was, in self defense, forced into making the last tests on the Norfolk & Western Railway, in order to determine the truth as to the action of the brakes in question.

It had already made a report on the Virginian tests of 1918 which was most vigorously attacked. In the Norfolk & Western tests the trains were operated in accordance with the rules of the road, but conditions were set up that were confessedly more severe than would be encountered in regular service. It is on the result of these tests that the report is issued.

Its conclusions set forth the general requirements that should be met in order to obtain the best possible results in train handling, and they start out with what has a mandatory appearance in the statement that "improvements in the operation of power brakes for both passenger and freight trains are essential and must be effected."

The commission has not, however, issued any order requiring any change or modification in air brake equipment or practice, but has left the case open for further consideration and consultation with the interested parties who are, first of all the railroads. These will probably have an opportunity to offer advice and make suggestions, after which we may look for some order changing the present air brake regulations, as this is distinctly intimated in the summing up of the conclusions, by the statement that "full specifications and requirements covering more fully the functions, maintenance and operation of power brakes and appliances should be adopted."

Brightening of Numbers and Lettering on Freight Car Equipment

The following circular regarding the maintenance of lettering on freight cars has been issued by Division V Mechanical of the American Railway Association:

Attention has been called to the need for brightening the numbers and lettering on freight car equipment, particularly those of steel construction. The Transportation Division advises that under present conditions it is extremely difficult for number takers to be certain that they have taken the correct numbers, and in consequence there are innumerable errors in the records which are costly to correct. The restoration of per diem accounting, effective October 1, 1919, makes it imperative that the stenciled letters and numbers on all freight equipment cars be maintained and the identity kept bright.

When the lettering or numbering is found in bad condition, the identity must be renewed by either repainting or by applying new stenciled letters and numbers.

If there is not sufficient paint on car to properly retain the new stenciling, and condition of car does not justify entire repainting, one coat should be applied as a panel back of the stenciling so that the paint used in applying the numbers and letters will hold, otherwise the marking applied will soon become illegible and make it necessary to again apply the identity marking within a short period. Before applying paint to steel, it should be scraped so as to clean off all blisters and loose paint.

One Example of the Economics Practised

The Southern Pacific Railroad in 1923 saved $2,531,878 through the accumulation and reclamation of material and supplies which otherwise might have been junked or discarded.

Out of the accumulation of scrap, $612,955 was saved through reclamation. In addition to this, more than 51,000 tons of scrap were sold for $665,584, while the Company itself used over again for other purposes 58,245 tons valued at $1,253,339.

The material reclaimed included couplers, brake beams, switch points, frogs, rail joints, type plates, spikes, lumber, brake shoes and castings of all kinds.

Maximum Loading of Freight Trains

A Method of Computing Adjusted Tonnage Ratings for Maximum Freight Train Loads

At the thirty-first annual convention of the American Association of Railroad Superintendents in June, 1924, the following was submitted as a report by a committee of which A. E. Boughner, superintendent of the Missouri-Kansas-Texas Ry., was chairman:

When this subject was discussed by our committee, two questions arose as to what was actually meant; whether it was desired to consider—(1) Maximum load behind the engine or (2) Maximum average train load for an entire line.

Inasmuch as the operation of freight trains on different lines differs in accordance with the service requirements, it was felt the maximum load behind the engine was the real subject, for the reason that if the maximum load behind the engine is maintained as constantly and consistently as the service will permit, the best average maximum trainload for the entire line will be obtained.

It is fully realized by your committee that the maximum load behind the engine, as well as a maximum average trainload for an entire line, does not necessarily mean the most economical train loads, due to the operating conditions, and it is therefore our desire to submit a plan of obtaining the maximum engine load based on established and tested plans and formulas leaving it to the individual line to determine what modifications, if any, should be made to meet local operating conditions. Accordingly we have reached the conclusion that the main factors in obtaining a maximum trainload are as follows:

1. Establishing a practical rating for the engine.
2. Require every engine to haul this rating the greatest distance possible.
3. Require all of the trains to do all of the time what some of the trains do some of the time.
4. A regular and accurate method of obtaining statistics, indicating what the engines are actually handling, so arranged that the information will reach those concerned in the shortest possible time after the train has been operated, and with it a system for following up the trainload closely, so that the attention of the officers responsible is constantly and immediately called to the failure of engines to handle the proper tonnage when such cases occur.

Taking up these subjects in the order they appear above:

1. It is our opinion that the best method for establishing a practical rating for the engine can best be arrived at by taking the theoretical tractive power of the engine to establish a so-called theoretical rating; this to be followed by actual tests should be conducted with a dynamometer car. It is our opinion that the question of adjusted rating is a very important one if the adjustment is properly worked out. A formula which has been successfully used is shown below: "Methods of computing adjusted tonnage ratings." The various resistances, etc., which are shown in this formula are those obtained after careful study and it is not felt for the purpose of this report that the method of arriving at these resistances is necessary, but rather that a formula that could be used by men in different branches of the transportation department would be most beneficial, the whole plan being dependent upon power being properly maintained.

2. The method shown in paragraph 4 will, to a very large degree, enter into this situation, but the important matter in connection with this subject, as we view it, is to confine the authority to reduce the established tonnage rating to as few men as possible and preferably to the chief train dispatcher alone.

3. How to make every train haul the rating is a subject that is of sufficient importance to warrant a paper on it alone. We hope to touch briefly the points which we regard as important.

(a) The proper building of the train in the yard so that the train will run intact as far as possible, which involves proper classification of freight and confining local work to the fewest number of trains.

(b) The calculation of tonnage should be delegated to an employee competent to make such calculations, and one who has been thoroughly instructed with reference to the ratings. Where the volume of tonnage handled is sufficient, we recommend the use of computing machines for this purpose, and that the tonnage record be taken from the waybill.

(c) On low grade lines where the trains are long, and the possibility of interruption to service by equipment defect is of sufficient importance, we recommend consideration be given to the marking of all weak cars in the receiving yard, and that they be switched separately and run in trains of reduced tonnage as often as the accumulation will permit, but at least once every twenty-four hours, thereby eliminating the weak car from the heavy tonnage train and avoiding the necessity of switching cars out on line and running other trains out light of tonnage to move them; and the delays incident thereto.

(d) Prepare for each yard a list of calling times, indicating a time at which trains may be called, providing a sufficient number of calls to move the maximum number of cars to care for the business, and have such list made with the view of avoiding confliction with other train movements, and then prohibit the running of trains at times other than the time shown. On some lines a schedule has been worked out for each of these runs over the freight district, which is helpful to supervising officers when encountering trains on line to be able to determine immediately upon learning when the train was called, whether the performance has been up to standard.

(e) The importance of providing a standard performance for tonnage freight trains over a freight district is not to be overlooked. A standard performance when reached and agreed upon can then be used as a measure by which all other movements may be judged.

4. It is difficult to outline a plan for compiling tonnage statistics that will be suitable for every railroad. The extent of the organization necessary to handle this important matter is dependent upon the volume of tonnage handled. A system which has been productive of good results is one which provides for the establishing of a 100 per cent performance standard for freight operation for each division, based upon either the cost per 100 gross ton miles in crew wages or in gross ton miles per hour of crew time, for a full rated train to pass over the district without overtime. Under this system there would be maintained a tonnage bureau, which may consist of one or more employes in the office of each superintendent, to whom a copy of the wheel reports covering the movement of all freight train service are sent each day. These wheel reports should contain not only the gross tonnage, but the tare and net as well. They will, of course, contain data showing the class of engine used, length of time on road, etc. This information is drawn off in the tonnage bureau as soon as possible after the wheel reports are received, and submitted to the superintendent and such officers as he may designate. It is usually kept in a tabulated form so that the officers may not only observe the

daily performance, but the performance of the division to date, and immediately observe their percentage of the of several freight districts, and where these districts are under the direction of an assistant superintendent or trainmaster, the records for each district are kept separate in order that the superintendent may immediately determine which district is dropping behind. This tonnage bureau also submits to the superintendent a statement for each yard on which is shown the trains that have been dispatched short of the engine's rating, and which permits of a continual following up of the matter. It is our opinion a standard based upon gross ton miles per hour on crew time is sufficient to enable the officers to determine quickly and accurately how their operation is running and that it is not necessary to maintain the statistics necessary to arrive at costs.

The question of adjusting the tonnage rating on account of temperature variations is one that has received a great deal of thought and study. It is our feeling, however, that rather than resort to a percentage reduction as temperature drops, that it is better to maintain the same rating for the engine and increase the adjustment with temperature variations. The adjusted ratings under such circumstances should be designated by the letters A, B, C and D; A being full rating, temperature above 35 degrees; B, 20 to 35 degrees; C, 0 to 20 degrees; D, below zero. It is, of course, generally known that tonnage trains are the first to be affected by cold weather. It is also recognized that trains which make almost continuous runs without stops are not affected as much by cold weather as trains on lines where the operating conditions require frequent stops and sometimes long delays. The effect of high wind is, of course, the same, regardless of the above conditions, and it follows, therefore, that the combination of high wind and cold weather should be amply compensated by reduced ratings, as not only is the train resistance increased, but the loss of power on the engine affects its hauling capacity. It is difficult to always predict the conditions a train will encounter on its trip, but the following should be carefully considered:

(a) Trains leaving a terminal in the afternoon will have the lower night temperatures to meet.

(b) Trains starting after midnight may find operating conditions better after the sun is up.

(c) Trains starting a run in low altitudes will find colder weather in the mountains.

(d) Trains starting in mountains may often take on tonnage in the low lands.

(e) Trains having many stops and starts will be affected by cold more than trains running continuously.

(f) Trains starting up grade on leaving a terminal will handle larger ratings if helped out of the terminal for 20 minutes until the journals become warmed.

(g) Location of passing sidings play an important part in rating trains in winter. If sidings are in such position that train starts out of siding on a downgrade or on a grade substantially less than the ruling grade, larger ratings may be handled than in the case where sidings are located on ruling grades.

(h) If trains move out of the terminal promptly and put in time on the road instead of standing in yards a better rating may be handled than when a larger part of the allowable time is being consumed in doing nothing.

By reason of the various temperature conditions in different parts of the country, it is difficult, if not impossible, to submit a plan for working out the adjustment necessary for the individual line. It is felt this could only be properly determined by actual tests on the line itself. For example, in the middle Atlantic states the train load will decrease from 15 per cent to 30 per cent in the winter dependent upon conditions.

The question of tonnage train speed is also an important one and we feel that high speed is not essential, but on the contrary is somewhat detrimental, and it is therefore our recommendation that the speed of slow freights be restricted to that which will permit an engine to handle its full tonnage over the line easily and without overtime.

We have purposely omitted any reference to fast freight or local freight ratings for the reason that the requirements of the service on the individual line will determine very largely both the fast freight ratings that it is necessary to establish, and the local freight rating. We would suggest, however, that the ratings be established in exactly the same manner as for tonnage freights and that the same consideration be given in establishing a standard, so that a maximum train load not only in fast freight, but also in local freight, will be obtained, and that the same statistics and follow up system be used. A careful check of freight moving under fast freight billing is also essential as it is frequently found that freight so moved is not entitled to fast freight movement, which unnecessarily increases the number of fast freights operated, and with a disastrous effect on trainload.

In conclusion, train loading is something that has to be worked out on every division, as there are two essential rules that must be considered in order to get the best results, namely, tonnage and time. To handle heavy tonnage on a single track railroad when traffic is dense, thereby consuming too much time is more expensive than handling a lighter train load at a faster speed. The problem, therefore, is to find out the economical train load. On some divisions the cost per ton mile on fast freights is lower than on tonnage freight for the reason that the freights can be kept moving practically all of the time while tonnage freights are required to remain in side tracks for the fast freights and other trains to pass. On other territories the reverse is true and in submitting this paper it is the hope of the committee that they have made suggestions which will be of assistance to the members in working out the best solution as indicated by their individual requirements.

Method of Computing Adjusted Tonnage Ratings

Loaded car resistance. Resistance on the level is 3.8 pounds per ton, that is, a loaded car weighing 70 tons (car and contents) requires 70 times 3.8 pounds, or 266 pounds draw-bar pull to keep it in motion at freight train speed on level track.

Empty car resistance. Resistance on the level is 8.3 pounds per ton, that is, an empty car weighing 20 tons requires 20 times 8.3 pounds, or 166 pounds, to keep it in motion on level track.

Grade resistance. Expressed in pounds per ton, the resistance of any grade is equal to 20 times the rate in per cent. That is a 0.3 per cent grade offers a resistance of 20 times 0.3 or 6 pounds per ton.

Curve resistance. The resistance of one degree of curvature has been found to average 0.8 of a pound per ton passing around it. That is, a 70-ton load moving around a one-degree curve on level track would require 70 times 0.8 pounds, or 56 pounds, of draw bar pull (in addition to the 266 pounds draw bar pull mentioned under loaded car resistance) to keep it in motion at freight train speed.

As curvature is given as so many degrees per 100 feet (a one-degree curve means one degree in one hundred feet, and a five-degree curve means five degrees in one hundred feet), and grade is usually stated as so many feet, or decimals of a foot, per 100 feet, it is customary to translate curvature into equivalent grade and then add this amount to the straight grade before calculating the grade resistance. As grade resistance in pounds per ton is equal to 20 times the rate of grade in per cent, the equivalent grade for any given degree of curve is found by dividing the curve resistance in pounds per ton by 20. From this it is evident that a one-degree curve with resistance 0.8 pounds per ton is equivalent to a 0.04 per cent grade, while a five-degree curve with resistance 4.0 pounds per ton would be equivalent to a 0.2 per cent grade. On what are termed compensated grades this procedure is unnecessary for the reason that the grades around the curves have all been reduced to allow for the curve resistance, that is, 0.04 per cent per degree.

Available tractive effort. If the theoretical tractive power of a locomotive is 54,600 pounds, it is found that at speeds of 8 to 10 miles per hour we have only about 41,900 pounds on straight level track, available for hauling train. This available draw bar pull is further reduced when grades or curves are encountered by the number of pounds absorbed in moving the engine and tender (232 tons) against such resistance.

Building a Train of 70-Ton Loads, or 20-Ton Empties for a 0.3 Per Cent Grade

Available drawbar pull of locomotive on level.....41,900 lbs.
Deduct grade resistance (232 tons times 6 pounds) 1,392 lbs.

Available for hauling train ....40,508 lbs.
Resistance of a 70-ton load on 0.3 per cent grade (266 pounds plus 420 pounds) .... 686 lbs.
40,508 divided by 686 gives 59 loads as hauling capacity
59 loads times 70 tons gives actual weight of train 4,130 tons
Resistance of a 20-ton empty on 0.3 per cent grade (166 pounds plus 120 pounds) .... 286 lbs.
40,508 divided by 286 gives 142 empties as hauling capacity.
142 empties times 20 tons gives actual weight of trains .... 2,840 tons

As the same resistance factors were considered in both cases it is evident that 142 empty cars weighing 2,840 tons pulls just the same on a 0.3 per cent grade as 59 loaded cars, weighing 4,130 tons. It is also evident that trains made up of cars having any other weights than 70 tons or 20 tons will show actual tonnages somewhere between the above limits of 4,130 and 2,840, and such trains would all require the total available drawbar pull (40,-508 pounds) of the locomotive on the 0.3 per cent grade. However, it is impossible to determine what these actual tonnages will be unless we figure out the resistance of each car and then keep totalling the resistance until we reach the limit of 40,508 pounds drawbar pull. This would, of course, consume a great deal of time and the following simple scheme was devised in order to get the desired result without undue effort.

(1) The hauling capacity of the locomotive in 20-ton empties and in 70-ton loads is figured for the given ruling grade.

(2) The difference in the actual tonnage of the two trains is divided by the difference in the number of cars and the quotient so obtained is called the adjustment factor.

For example:

On a 0.3 per cent grade this locomotive can haul

	No. Cars	Actual Tons
In 20-ton empties	142	2,840
In 70-ton loads	59	4,130
Difference	83	1,290

Adjustment factor (1,290 divided by 83), 15.5 tons per car. (As the result is an approximation we use 15 tons.)

Using the above adjustment factor instead of the longer method previously outlined, the following results are obtained:

Hauling capacity of this locomotive 59 70-ton loads ....4,130 actual tons

Adjustment—59 cars at 15 tons per car...... 850

Rating in adjusted tons 4,980
Hauling capacity of this locomotive 142 20-ton empties ....2,840 actual tons
Adjustment—142 cars at 15 tons per car....2,130

Rating in adjusted tons 4,970

The figured rating for this on a 0.3 per cent grade is 5,000 adjusted tons (with adjustment 15 tons per car). The difference indicated is due to not figuring on fractional parts of cars.

From the above it is evident that by taking 5,000 tons (adjusted) as the rating and considering 70-ton loads as weighing 85 tons and 20-ton empties as weighing 35 tons, we can build trains of loads, or trains of empties, or trains of loads and empties mixed, that will all require the same drawbar pull (40,508 pounds) to haul them on a 0.3 per cent grade. This is, of course, the principal object of the adjusted tonnage rating scheme.

Building a Train of 70-Ton Loads, or 20-Ton Empties, for a 1.0 Per Cent Grade

Available drawbar pull of this locomotive on level track ....41,900 lbs.
Deduct grade resistance (232 tons time 20 pounds) 4,640 lbs.
Available for hauling train ....37,360 lbs.
Resistance of a 70-ton load on 1.0 per cent grade (266 pounds plus 1,400 pounds) .... 1,666 lbs.
37,360 divided by 1,666 gives 22 loads as hauling capacity.
22 loads times 70-tons gives actual weight of train 1,540 tons
Resistance of a 20-ton empty on a 1.0 per cent grade (166 pounds plus 400 pounds) .... 566 lbs.
37,360 divided by 566 gives 66 empties as hauling capacity.
66 empties times 20 tons gives actual weight of train 1,320 tons
To determine the adjustment factor for a 1.0 per cent grade:

	No. cars	Actual tons
A train of 70-ton loads	22	1,540
A train of 20-ton empties	66	1,320
Difference	44	220

Adjustment factor (220 divided by 44), 5 tons per car.
To determine the rating of this locomotive on a 1.0 per cent grade in adjusted tons:

Hauling capacity 22 70-ton loads ....1,540 actual tons
Adjustment—22 cars at 5 tons per car 110

Rating in adjusted tons 1,650
Hauling capacity 66 20-ton empties ....1,320 actual tons
Adjustment—66 cars at 5 tons per car 330

Rating in adjusted tons 1,650
Comparing the ratings and adjustments obtained for the 0.3 per cent and 1.0 per cent grades:

	0.3 per cent Grades No. cars	0.3 per cent Grades Actual tons	1.0 per cent Grades No. cars	1.0 per cent Grades Actual tons
Trains of 7-ton loads ...	59	4,130	22	1,540
Trains of 20-ton empties	142	2,840	66	1,320
Difference	83	1,290	44	220
Adjustment factor	15		5	
Rating of this locomotive in adjusted tons......	5,000		1,650	

Inspection of the above figures indicates that if carried out far enough a grade would be found (a very heavy one) on which hauling capacity in loads or empties would be just the same and under this condition adjustment would be zero.

Power Brakes on British Railways

By W. E. SYMONS

In the March issue of RAILWAY AND LOCOMOTIVE ENGINEERING, we presented for our readers a review of the power brake situation in several foreign countries, pointing out the fact that the standard brakes used in the United States had recently been adopted in France and other countries.

The rather peculiar situation as to power brakes in India was also set forth in our columns in the form of notes made and information gathered by an international traveler who had been on the ground and spoke from first hand information. As India is an English province, we felt that the standards or practices followed there might be closely related to that of the mother country. We therefore requested our London correspondent to briefly review the situation at present in England, and present below his comments and impressions based on personal observation and inquiry.

Vacuum and Air Brakes in Britain

"It is remarkable the tenacity with which the British railway men cling to their old favorite vacuum brake. The recent fusion or "grouping" of the various railways brought forward the question of unification of the brake systems used, and it appears, if our information is correct, that the vacuum brake will probably be accepted for general adoption or standard for main line service throughout the amalgamated systems. This, in spite of the adoption of the air brake for the European railways, the conversion from vacuum to air of the Japanese and Dutch Indies systems, and the impossibility of getting the vacuum into successful operation on the India freight trains; truly the Britisher is most conservative.

London & North Eastern Railway 15 Car Train With Westinghouse Air Brake

"Prior to consolidation or grouping, a number of the British railways had adopted the Westinghouse air brake for all passenger trains whilst others used the vacuum; the majority the latter. The actual figures of vehicles equipped with the different apparatus were approximately as follows: 14,270 with the air brake, 42,500 with the vacuum brake, and there were 10,900 "dual" fitted, or equipped with both systems to enable interchange of passenger stock. Many of the locomotives are also fitted with appliances for operating both forms of brake. This divergence in the type of power brake used was not the only serious variation in operating appliances that the British railways suffered from and it was the hope of securing uniformity in such matters that formed a strong inducement for amalgamation.

"Various committees of inquiry have been held and apparently as much discord has been evinced at these meetings as when the famous "Battle of the Brakes" was being fought in 1875, then the opposing forces almost came to blows.

"Whilst it may be conceded the vacuum brake apparatus used at present on the British passenger trains is simple in construction, cheap to maintain, and satisfactory as a power brake for light service, it has its limitations and when the trains exceed a certain length, trouble arises due to the difficulty of the locomotive to maintain the requisite vacuum and to its inability to re-create vacuum for the quick release of the brakes after a full application. It is this latter weakness in quick operation which has compelled the electrified lines to adopt the air operated system of braking. There are only one or two electric railways which use vacuum brakes and these are in the provinces.

London & North Eastern Railway 10 Car Train With Vacuum Brake

"In Great Britain the compulsory law, at present, only applies to trains in the passenger service, consequently only these have power brakes in operation; freight trains are so far exempt and are still controlled by the antiquated method of attaching weighted brake vehicles or vans on which the brakes are manipulated by hand. A few fast freight trains conveying fish, meat, and perishable commodities are run with continuous brakes in partial operation, never braked throughout, this due to the difficulty of maintaining the continuous vacuum. The railways have made attempts to overcome this trouble by employing air pumps actuated from the cross-head of the locomotive, using a steam ejector for release purposes only. This remedy has been found to be as bad as the disease, for the pump is only effective at high speeds, at low it fails to exhaust the train pipe quick enough to prevent the brakes creeping on from leakage, and only one of the grouped administrations appears to favor it sufficiently to continue its use; that is the Great Western.

"To an American observer, it must appear paradoxical to see a train of 40 to 50 fully equipped vehicles pass, having the brake pipes disconnected at the 25th or 30th car thus putting the power brake out of operation at the rear of the train and preventing the benefits of automatic action being secured for the rear van or "caboose." This is the actual everyday working of the British railways so that there is no reason to be surprised at the serious effects of breakaways, etc., that we often read of.

"Some very interesting experiments were recently made on a section of the London & North Eastern Railway where the Westinghouse air brake has been standard for many years. A train from another division using the vacuum brake was made up to the full length of the air braked train and ran on one of the suburban services out of Liverpool street, London. It was sandwiched into running to see how it compared in efficiency. The results were found to be so very unsatisfactory from a time-keeping point of view that it has been decided to retain the air brake for steam services on this particular section. It is unfortunate that your British cousins will not take advantage of your experiences before committing themselves entirely to such a poor substitute for an effective power brake." *"Veritas Erat Victa."*

The foregoing is most interesting indeed, as on analysis, it portrays clearly the failure of our English cousins to recognize both from an economic and transportation standpoint the known weakness or inadequacy of a certain type of power brake, and substitute in its place one of demonstrated efficiency and economic superiority.

We are loath to ascribe a reason or tender an explanation lest we might be considered uncharitable toward those who in many other railway engineering or operating questions, we are glad to endorse.

Are we in error, or too brutally frank if we suggest that the influence of the vacuum brake has almost if not completely obscured the vision of those who have to do with the design of modern equipment and the devices and appurtenances essential to a high degree of safety in train movement or economy in operation.

We may be in error, but we submit that the action, or inaction, of our British cousins both at home and abroad on the power brake question justifies the suggestion that they are lagging far behind their record in many other fundamental features of railway engineering.

Through the courtesy of our London correspondent, we are also able to present photographs of two passenger trains of English railways. One is on the London and North Eastern Railway on Holloway incline at London and consists of ten (10) coaches equipped with the vacuum brake. The other is also of the London and North Eastern Railway at Wetherall Green, London, of fifteen (15) coaches equipped with Westinghouse brakes.

Snap Shots by the Wanderer

A Suggestion as to Dining Cars

I have frequently taken a shot at the dining car, and the apparently hopeless financial condition in which it finds itself. It has been very easy to criticize but to offer a constructive criticism is quite another matter, except on the general principle that an old maid who has never had any children can always offer many suggestions on the training of offspring to the mother of ten.

With this implied achnowledgement of a lack of experience in the operation of dining cars, I have a constructive suggestion to make that may or may not be of value. But the very fact of its being offered carries with it the belief in its practicability.

In order to put it into effect, however, there is one idiosyncrasy of human nature that will have to be ignored, and to which the dining car superintendent has, heretofore, catered with unremitting zeal.

The average man, especially the average man who has not been accustomed to very much of luxury or possibly of comfort at home, immediately becomes imbued with a desire for all the frills and luxuries of the age as soon as he starts to travel and especially if he is traveling at someone else's expense.

At home he will sit down to table and be quite content with a roast, one or two vegetables, some bread and butter and a piece of pie for dinner. Abroad he is unhappy unless he has a choice of all the meats and delicacies that the market affords.

At home he does not grumble at the carrying of a scuttle of coal from the cellar to the kitchen, and even abroad he may carry his satchel half a mile from the station to the hotel; but let him step inside the portals of the inn and he is straightway seized with the weakness of a paralytic, and considers himself abused if a bellboy does not rush up and snatch his burden to carry it the remaining twenty feet to the desk. Nor is he capable of carrying it to or from his seat in a Pullman car.

The point made, is it worth while to cater to such foolish and absurd idiosyncracies when it costs good solid dollars to do it and for which there is no return.

This is exactly what the dining car superintendent has tried to do and failed. He has tried to rival a big restaurant in the elaborateness of his menu, without the facilities of meeting its requirements. He has attempted to cook a multiplicity of meats and vegetables in quarters too limited to warrant anything but the simplest of efforts. And, as a result, he has been driven to charge prices that to the majority of passengers are prohibitive and to all exorbitant or unsatisfactory. Without thinking he has followed in the wake of the big restaurants and served too large portions of some things and too small of others. And in it all there is general dissatisfaction. Dissatisfaction on the part of the public who pay high prices for rather poorly cooked food, and dissatisfaction on the part of the railroad management, at being obliged to run a charity restaurant.

Now for the experience that led to my suggestion.

I was in a dining car recently for lunch and dinner. It was running on one of the big lines and its menu included five kinds of meat and fish, with all imaginable outsides, so that for lunch there were eighty-six items on the bill of fare, while for dinner it was cut down to a modest eighty-three.

I looked over the car. The patrons were an ordinary lot, like myself, probably accustomed to good food at home, with possibly one kind of meat, and at the most six or seven other items for a dinner. With that they were probably satisfied, and better satisfied than with the pot-pourri of mixtures with a uniform taste that come from the dining car kitchen. That home cooking is supposedly popular is evidenced by the signs displayed by restaurants stating that they have it, and which they never do.

Now that menu of eighty-three and eighty-six items is what I call catering to that idiosyncracy of human nature that demands more than it has ever been accustomed to or has a right to expect as soon as it steps out of its own modest little home.

It so happened that this dining car, with its elaborate menu, carried me towards a summer hotel. A hotel which, if I guess right, was filled with guests having an average of cultivation and refinement far and away above the average of the patrons of that dining car; people who were accustomed to "live well at home."

Speaking casually with a goodly portion of these guests I found them loud in the praise of the house and especially of the table. Mark you they were content and satisfied.

Then came the thought that is embodied here, that of showing the difference between a satisfactory menu and one that is not. Here follow the bills of fare for the three meals of a day, taken at haphazard and without selection.

BREAKFAST

Plums, preserved figs, grape fruit and marmalade, rolled oats, shredded wheat biscuit, boiled scrode, beefsteak, bacon and eggs, baked potatoes, white rolls, bran muffins, tea, coffee, milk.

DINNER

Tomato soup, baked shad, rice cake with raisins, roast beef with dish and brown gravy, fricassee of chicken, cranberry sauce, boiled and mashed potatoes, string beans, boiled onions, apple pie, Washington pie, chocolate ice cream, cheese, tea, coffee.

SUPPER

Escalloped clams, broiled white fish, veal cutlets, tomato sauce, jellied fruit salad, cold beef, ham, tongue, creamed potatoes, hot rolls, hot ginger bread, apricots, apple jelly, assorted cake, tea, cocoa.

There we have quite a satisfactory menu for a day, with fifteen items for breakfast, seventeen for dinner and sixteen for supper, as compared with five times as many for the dining car.

The hotel menu required the immediate cooking of ten items for the dinner, the dining car of forty-eight, still maintaining the five to one ratio.

The hotel had the advantage of a large well ventilated and commodious kitchen; the dining car chef was limited to a space of about fifteen feet by seven, and worked wedged in between the range and the wall of the car and yet was asked to cook five times as many items as the woman at the hotel.

Of course, he could not do it satisfactorily and never will. Then why force him to try? But perhaps he has given up hope and has ceased to try, certainly his output often indicates that something of that sort has happened.

The dining car superintendent has tried to achieve the impossible and has most gloriously failed. There are many reasons for this. Possibly chief among them being the fact that the other fellow does it. It is like music in a restaurant. They all have it because they all feel they must, though it is doubtful if music ever brought people because it was there; least of all enough to pay the expense of it.

The dining car was a luxury at first, to avoid the delays of a stop and the annoyance of a rush to a wayside restaurant for meals. Now it has become a necessity, but being such, it does not follow that it is necessary to smother it with an elaborateness that nobody wants, and achieve a result with which nobody is satisfied.

The advantages of the simplified menu, as I see it, are that it would make better cooking and better and more rapid service possible; that prices could probably be profitably lowered; that more people could and would be served as a combination of the other two; that patrons would be better satisfied, and would go to the dining car not because they must but because they wanted to.

But, and here's the rub, who will have the courage to tell the public that it is acting like a pack of fools to ask for so much, simply because they are away from home, and say to them "take this or go hungry, for it's all you're going to get, and write it down that that little is far more and better than you ever had at home?"

To set an example to the superintendent of competing roads, and tell them that they too are foolish and that their dining car is not only an expense, but has not even the merit of being a good advertising medium as they have all been so assiduously preaching for so many years?

This will take the real spirit of the pioneer and reformer, especially as it is the one thing that has not yet been really tried; that of furnishing simple, well cooked meals at a moderate price. It seems to me, who am quite devoid of experience, that it would at least be worth a trial. If it works in a hotel why shouldn't it in a dining car? Why not strive for that recommendation that can be purchased in no other way? "Their bill of fare isn't elaborate, but what they have is good."

Meeting of National Safety Council

The 13th annual safety congress of the National Safety Council will be held at Louisville, Ky., September 29 to October 3, inclusive. The sessions of the steam railroad section will be held at the Seelbach hotel, September 30 to October 2, inclusive. The officers of the steam railroad section are: Chairman, Fred M. Metcalfe, superintendent of safety, Northern Pacific Ry.; vice chairman, Charles E. Hill, general safety agent, New York Central Lines; secretary, E. R. Cott, Hocking Valley R. R., Columbus, Ohio.

At the opening session, Tuesday morning, September 30, two important papers will be presented, as follows: Better Management Through Co-Operation, the safety Method, by Henry Bruere, director, Chicago Rock Island & Pacific Ry., and vice president, Metropolitan Life Insurance Co.; and Development of safety on the Railroads, by Charles Frederick Center, New York Central Lines.

Wednesday's session includes a symposium of addresses on safety from the viewpoint of the various departments: The transportation department, by Edward G. Neuman, Union Pacific R. R.; the car department, by W. A. Clark, Duluth Missabe & Northern Ry., Duluth, Minn.; the track department; the locomotive engineer, by Daniel J. Buckley, Baltimore & Ohio R. R., Staten Island, N. Y.; the shop man; the conductor; the trainman, by F. G. Kileen, Wabash Ry., St. Louis, Mo. Following this will be a safety inspectors' session, with J. A. McNally, Wabash Ry., St. Louis, Mo., presiding as chairman.

The following papers are on the program for the concluding session of the railroad section, Thursday morning, October 2: Presentation of Inspectors' Problems, by J. A. McNally, safety inspector, Wabash Ry.; Organizing and Maintaining Interest Among Committeemen, by H. S. Corbin, supervisor of safety, Atlantic Coast Line; Acquiring a Safety Conscience, by W. L. Allison, Baltimore & Ohio R. R., Chillicothe, Ohio; Getting the Co-operation of Local Safety Committeemen, Local Officers and Labor Representatives in Correcting Unsafe Practices, by D. E. Satterfield, safety inspector, Chesapeake & Ohio Ry., Richmond Va.; Interesting the Individual in Safety Work, by J. A. Clancy, safety representative, personnel department, New York New Haven & Hartford R. R.; general discussions of problems of inspectors and supervisors.

The Heating, Ventilating and Lighting of Passenger Cars on the Pennsylvania Railroad

An Outline of the Work of the Railroad in the Development of the Systems Used

By GEO. L. FOWLER

Those who take for granted the comfort afforded by present railroad travel, find it difficult to realize that there must have been a beginning to these good things, and that there was a time prior to the use of steam heat when the car stove, the open window and the kerosene lamp were the only means by which the three desirables could be effected.

In the matter of heating, the Pennsylvania was among the first of the railroads of the country to use steam taken from the locomotive for the heating of its passenger trains. In a way, the matter was forced upon the attention of the mechanical officers. Certain experiments were made with methods of heating cars by steam taken from the locomotive. They were crude, not altogether satisfactory, and merely gave indications of possibilities. But the promoters raised such a hue and cry as to the danger inherent in the use of the car stove, that legislatures were stampeded and long before the system had been properly developed, laws were passed requiring the abolition of the car stove and the substitution of steam taken from the locomotive. New York was the first to enact such a law. Owing to the imperfect condition of the systems then upon the market the subject was studied critically at Altoona in order to determine as to whether steam or hot water circulation would be best.

Mr. John A. Collins, the mechanical engineer, thought the hot water system to be the best, and that an artificial circulation could be provided by having a pump in the baggage car to do the work. This arrangement, with the proper piping through the car, with a means of admitting air in from the bottom of the car, produced a very delightful heat, and an exhibition train was run between Philadelphia and New York. But the plan was too impracticable. The pipes were large and the couplings heavy, which together with difficulties experienced by freezing prevented it from going beyond its experimental stage.

Then the many accidents which occurred, some of them fatal, due to the bursting of high-pressure steam pipes in which from fifty to sixty pounds pressure were carried, led to the belief that that should be avoided.

The successful use of the vacuum system of circulation, which, to a certain extent, had come into use for the heating of buildings, suggested that it might be so modified as to be applicable to train heating. Elaborate experiments were made along these lines and an especially designed vacuum pump was finally placed on the tender. The system adopted and which had been developed at Altoona, was to take the steam at a reduced pressure from the locomotive and lead it across to the tender, where it was used to drive a vacuum pump. The steam of the same pressure was carried back to the rear of the train thorugh a direct line of pipe, branches being led off therefrom to the radiators located along the sides of each car. The discharge from the radiators was led to a return pipe leading to the suction of the vacuum pump, which thus maintained a constant circulation. The steam and water of condensation on the return passed through a coil of pipe submerged in the water of the tender so that all steam was condensed and the discharge from the pump was water delivered into the tank. A modification of this was used in mild weather when the exhaust from the pump was alone used to heat the train. With this method there was really very little waste of heat. All of the heat contained in the steam was either radiated in the cars for heating purpose or was delivered to the tender where it served to raise the temperature of the water contained therein, the only loss being that radiated from the hose connections between the cars.

They were enabled, in this way, when the apparatus was in good order, to heat trains of from twelve to fifteen cars, and with no pressure beyond the two or three pounds existing at the inlet pipe and diminishing to a vacuum which was not very high, although it frequently rose to from twenty-two to twenty-three inches.

An interesting development of the early experiments was the effect of the rubber hose which was allowed to hang down between the cars in the usual way. In testing the vacuum pumps on the hill grade at Altoona to ascertain as to whether it would be possible to lift the water while on a grade, it developed that the pump would not raise the water through the whole length of the long train; when it occurred to someone in charge of the experiments, that these hanging rubber hose were really but adding to the height of the lift by the amount of their own drop. By decreasing the drop the trouble was remedied.

This vacuum method of car heating was efficient and satisfactory and was used for a number of years, but was gradually abandoned, as there was more or less difficulty involved in its maintenance and operation, and finally was entirely supplanted by the more refined methods of steam heating that had been developed.

Closely associated with the heating of cars was that of their ventilation to which a great deal of personal attention was given. The subject was studied very carefully and elaborately by filling the cars with men from the shops and taking specimens of the air and analyzing it to see what the effect of the different systems of ventilation might be, when applied to the air of a car. It soon developed that the ordinary ventilation produced by opening the windows and transoms in the side of the car below the ceiling did not produce good ventilation, it simply removed any air that might come in casually through the car. On the very short runs, where the stops were frequent and the doors opened just as frequently, this seemed to answer very well. It was on the strength of this defect that the system afterwards adopted was developed and brought into a thoroughly satisfactory working condition about 1900. It was patterned after the old air hood used in the old Spear stoves. In its general principle the system was very simple. It consisted of taking the air from the outside through two hoods at diagonally opposite corners of the car, thence through downtakes underneath the hoods to spaces, one on each side, underneath the car floor, the false bottom, the outside sill and the nearest intermediate sill forming the walls of the same. These spaces which have a section of about fourteen inches by seven and one-half inches extend the whole length of the car. From these spaces the air passes through the floor by means of proper apertures, over the heating system and thence out into the car, and finally escapes through ventilators situated on the center line of the upper deck. With this system it is possible to pass about sixty thousand cubic feet of fresh air through the car each hour or about one thousand cubic feet for each passenger, while the heating system would raise it to a comfortable temperature. In the details of the arrangement provisions were made for the proper filtration of the air so that it was not only chemically pure, but free from dust and cinders.

Another item of great importance to comfort was that of passenger car lighting. Here, again, the Pennsylvania took a stand that was seemingly in opposition to progress. The early cars had been lighted by candles and afterwards Mr. Ely took charge. As great an improvement as it was the kerosene oil lamp, and this was the system in use when over the candle light, the public became accustomed to it and demanded something better. Accordingly an investigation was begun leading into an improvement of car lighting. Although electric lighting was in its infancy, a train was equipped with incandescent lights, furnished with current by Faure storage batteries and was run between Philadelphia and Jersey City. This was, however, too much in advance of the times and was soon abandoned.

Following the kerosene lamp, the Pennsylvania introduced a regular system of gas lighting using the ordinary coal gas compressed to about fifteen atmospheres pressure and carried in storage tanks beneath the cars. This gas was purchased from the local gas companies at a number of places along the line and was controlled by special regulators in the cars. When the system was introduced the gas supplied was of a good quality and the lighting of the cars was satisfactory, but as time went on and improved methods of manufacture were introduced, the quality of the gas deteriorated until it became quite impossible to use it. The compression caused excessive deposits to be made, and the tarry and aqueous residue gave no end of trouble.

When this condition of affairs had been reached, the compressed oil gas was offered, but it was not, at the time, considered to be enough better than the ordinary coal gas to warrant an entire change of methods, though very great influence and pressure was brought to bear to adopt this new method.

Attention was then directed to the Frost light which is a system of gas illumination in which the gas is produced by passing air through a carbureter packed with wicking that has been saturated with gasoline. As first presented for use, the apparatus was not in such shape as to give a satisfactory light, but such modifications were made in the details that the flame produced was brilliant and the illumination all that was desired. In the course of this development, it was first found that the gasoline was very sensitive to changes of temperature and that means had to be found to overcome the effects of cold weather. The problem was solved by cutting a hole through the center of the carbureter, putting a coil of pipe therein, through which the air passes on its way to the carbureter, and in which it was heated by the flame of its own jet in the car beneath; compressed air being used as the source of supply.

Then the advocates of the rival systems raised the question of its safety and there was such slaps and bitter attacks upon it from that point, that the controlling officials of the road were disturbed and anxiously questioned as to whether it was not an assumption of unwarranted risk to use so dangerous a device, and one that, it was claimed, was so liable to explode if the car was wrecked and the carburetter exposed to the heat of a flame or undue temperature.

In reply, the superintendent of motive power invited the critics to a demonstration. He first took a carburetter that was charged with gasoline and ready for service, and built a bonfire around it. Nothing happened. "But," said the critics, "that does not repeat the conditions existing in an accident, when the carburetter would be damaged and likely to have holes punched in it so that it would leak."

A carburetter was then taken to a steam hammer and pounded until the casting was split and it was quite out of shape. The bonfire test was repeated with no more effect than before as far as explosions were concerned, and this put an end to any consideration of the hostile criticisms.

This light was used for a number of years and during the whole period, though between eleven hundred and twelve hundred cars were equipped with it, there is no record of any accident having occurred that could be attributed to the system.

During this period the method of lighting by gas was considered a refinement and was confined to the eastern lines, oil being used on the western lines and branches. But as the outside systems were developed, improved, and the cost of operation cut down, it became economically possible to abandon the Frost light and adopt that of the compressed oil, or Pintsch gas, which was done.

These are some of the more important of the details that had to be developed and perfected in order to effect the change that had been made in the character of the accommodation afforded the passenger both in the matter of comfort and of safety. But of it all, the change from the wood to the all-steel construction of passenger cars and to the steel underframe construction for freight cars is the most important. The resolution effecting both of these changes were passed by the board of directors during Mr. Ely's regime. So that, in the official life of this one man on the Pennsylvania he had seen the wooden freight car of ten-ton capacity, with hand brakes, and cast iron wheels, link-and-pin couplers grow and change to the steel cars of fifty tons capacity, with air brakes, automatic couplers, and steel wheels, quintupling the carrying capacity and cutting the ratio of dead to paying load down from one hundred percent. to thirty-six per cent., and this revolutionizing the freight work of the country. He had seen the short wooden passenger car, with light underframing, and carried on cast-iron wheels, illy ventilated and more illy heated coupled with link-and-pin couplers and controlled by hand brakes, grow in length and weight and luxury of appointment, until it suddenly burst forth as the all-steel car of the latest type of equipment. In this growth he had seen the application of the air brake go from straight air to the high speed and later development of the triple valve; the automatic coupler come into its own and with it the vestibuling of the platform; the old bell cord disappear and the air signal take its place. The trucks have taken on an extra pair of wheels; the lighting has been perfected; real ventilation has been introduced; heating that means comfort and not merely a high temperature is used; and, so, along the line in everything that makes for comfort, safety, speed has come until the old is not only old but archaic and it hardly seems that such conditions should have been. And, when it is borne in mind that, in all these changes, the acts of the man are covered by the time in which he lived and how the road on which he worked was responsible, by its policy for the much that he and others were able to accomplish.

Freight Train Speed

Reports of the Bureau of Railway Economics show that: The average freight train speed in the first six months of this year was 11.4 miles per hour compared with 10.7 a year ago.

The net ton-miles per train-hour in the first six months of this year was 7,933 compared with 7,560 a year ago.

Shop Kinks

Handy Devices That Were Developed in the Richmond, Va., Shops of the Chesapeake & Ohio Ry.

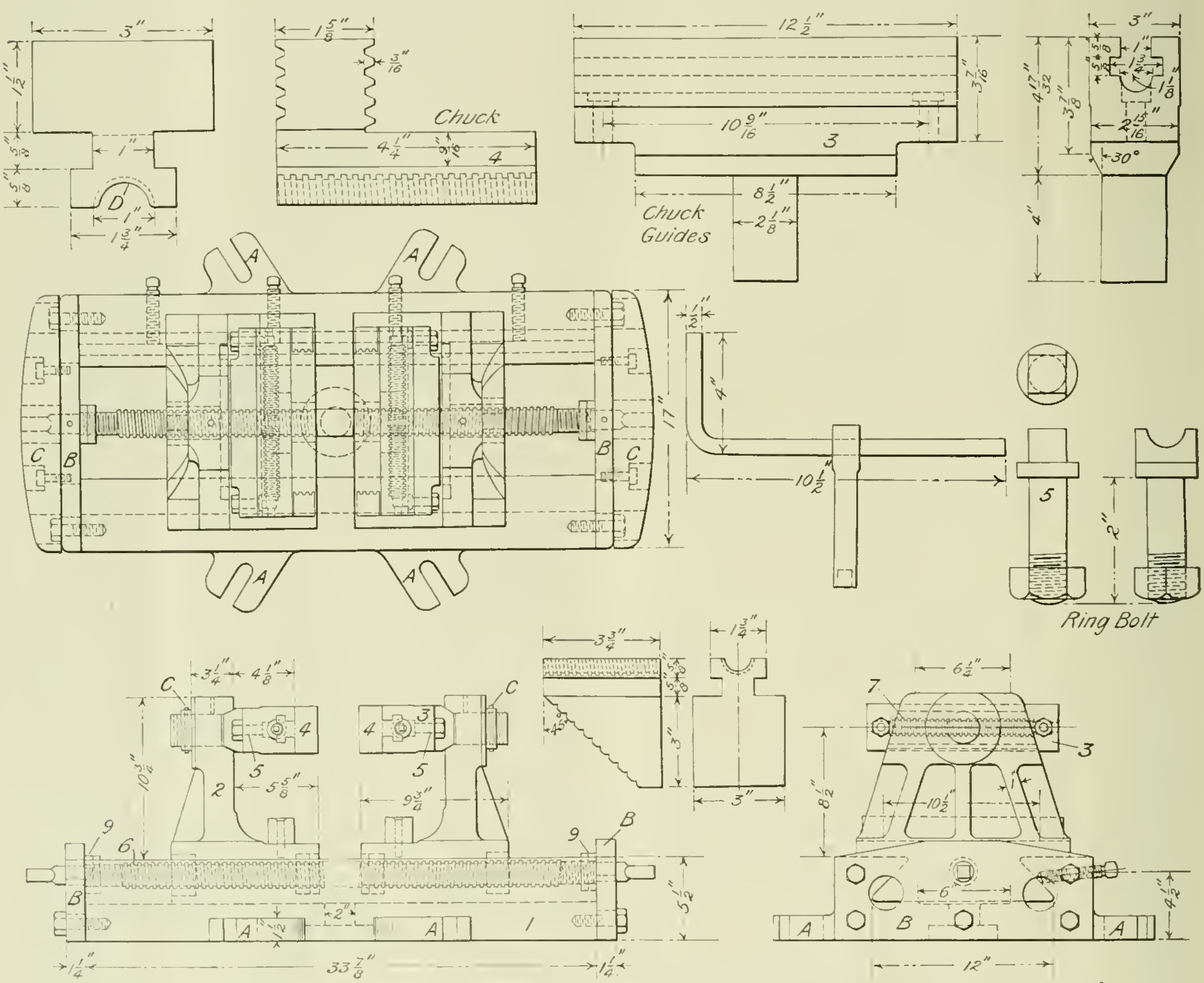
The Moss Universal Chuck

All of the tools and devices that are illustrated in this section of Railway and Locomotive Engineering have a value of their own in the particular place for which they were designed and are worthy of imitation by those who have work to do of that same character. For the most part they are clever adaptations of well-known principles or ideas to a special purpose that "any mechanic skilled in the art," to use a patent litigation phrase, might design. They are usually open to the world to imitate and copy. Occasionally, however, a design of such novelty is brought out that it warrants an entry into the patent office and a place upon the market. Such a device is this universal chuck that is here illustrated. It was designed in the 17th street shops of the Chesapeake & Ohio Ry. at Richmond, Virginia, and is now being manufactured by the Commonwealth Supply Co. of the same place.

It is intended primarily for use on boring machines for doing such work as boring and facing driving boxes, turning and boring bushings, rod brasses and the like.

There is a base 1, which, in the size of chuck here shown, has a total length 33$\frac{7}{8}$ in. It is made of cast iron and is provided with four slotted lugs *A* by which it is to be bolted to the table. These lugs and their slots radiate from the center of the chuck by which it can be readily adjusted so that its center coincides with that of the machine upon which it is to be used. The base has a total height of 5½ in., and is finished on its top and bottom surfaces and at the ends. It is also fitted with a dovetail groove from end to end to take the main carriages 2. These are also of cast iron and are made with a dovetail to fit into the groove of the base. These downward projections of the dovetails are cut with a right and left hand thread respectively to take the corresponding threads of the screw.

The main screw 6 runs in bearings in the soft steel plates *B* which are 1¼ in. thick and are bolted to the



Details and Assembly of Morse Universal Chuck

Morse Universal Chuck as Applied to Boring Machine

ends of the base. The main threads are of the Acme types, 1¾ in. outside diameter and cut 6 to the inch. At the ends of these screws there is a smaller screw 1½ in. in diameter and 2 3/16 in. long cut with 12 threads to the inch on which two washers 9 are screwed. These washers thus serve as thrust bearings to hold the main screw in place and also as a means of adjustment by which their own wear can be taken up and the main screw 6 so adjusted that the carriages 2 will always be at the same distance from the center and thus hold the work accurately.

As a safety device a wooden block *C* is bolted by tap bolts, let into countersunk holes, to the outside of the plates *B*, as shown in the plan. This serves to protect the projecting ends of the screw and the holding bolts. Of course the ends of screw are squared for the wrench.

The top and front and inside faces of the carriages (2) are finished and their bosses are bored with a hole 2⅛ in. in diameter. This is to receive the chuck guides 3 which are made of machinery steel and are finished all over.

They are held in place by a washer and pin *C* the latter going down through a hole drilled in the trunnion portion of the chuck guide. There are two of these holes drilled in the trunnion, the purpose of which will appear later.

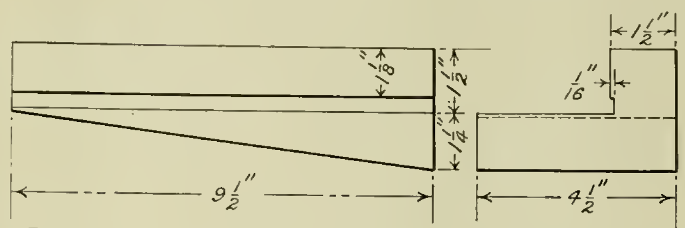
The chuck 4 is made with a sliding tenon to fit in the groove of the chuck guides and is cut with a half thread in the curved portion at *D* to take the crossfeed screw. There are four of these chuck pieces, two cut with a right hand and two with a left hand thread. The biting portion of the clutch projections are made so that they can be reversed and, at the same time hold the work in the central position both ways. The chuck screws 7, of which there are two, are cut with right and left hand square threads 1 in. in diameter, and 6 to the inch. They are squared at each end for a wrench and also have a bearing, next to the squared part, that is ⅝ in. in diameter and ⅝ in. long. These bearings turn in the grooved end of the bearing bolt 5. This bolt is let into a countersunk hole in the chuck guides. Its collar fits into and fills the counterbore and it is held in place by its nut as shown.

The chuck, as here shown, is reversible, that is to say the work having been finished on one side can be turned over for finishing on the other.

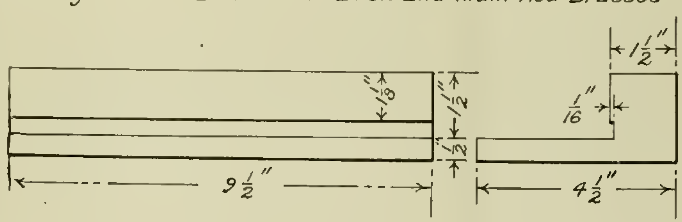
In operation the work is placed between the jaws of the chuck, and, by the use of the main and chuck screws, it is properly centered. When the boring and facing on one side is done, the pins, holding the chuck guides in place against the grooves in the carriages, as shown in the assembled illustration, are withdrawn and the carriages separated until the pins can drop into the outer holes near the end of the trunnion. The distance from center to center of these holes is a trifle more than the depth of the guide groove. So that when the pins are in the outer holes, the chuck guides, with the chucks and the guides, are free to revolve on their trunnions. By giving them a half revolution and running the carriages back to their original position the work is reversed.

Various forms of chuck jaws may be used to hold the different classes of work. The chuck jaws for rod bushings are triangular and form a four-jawed chuck.

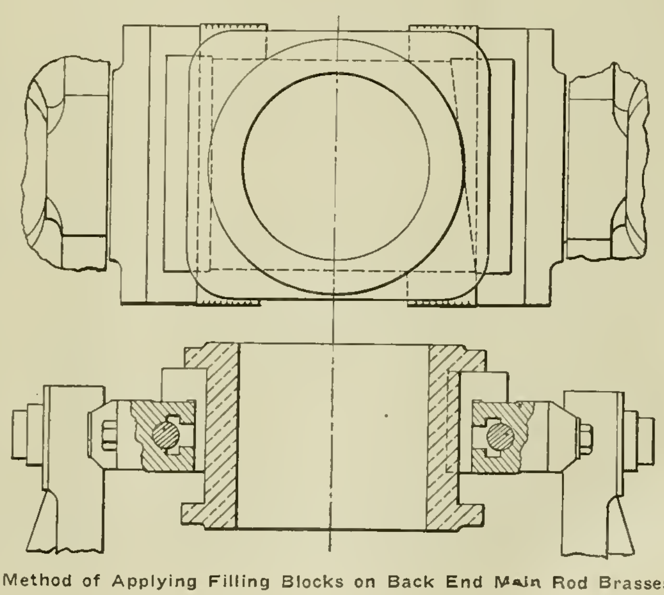
Where the piece to be operated upon can-



Filling Block for Back Half Back End Main Rod Brasses



Filling Block for Front Half Back End Main Rod Brasses



Method of Applying Filling Blocks on Back End Main Rod Brasses not be held by the direct contact of the chuck jaws, filling pieces are used. They are dropped in between the chuck jaws and are brought to a bearing against the piece by the main screws moving the carriage, and then the side clamping is done by the chuck jaws in the usual manner.

The details of two of these filling pieces and the method of applying them to hold the back end of a main rod brass is shown in the engraving.

Socket wrenches are used for manipulating the screws. That for the main screw is finished with a ¾ in. bar 22 in. long, while on the cross screws a wrench having a crank handle is used.

The Present Status of Train Control

In hearings before the Interstate Commerce Commission in May, representatives of the carriers made the following points in respect to the I. C. C.'s orders for the installation of automatic train control devices on certain lines.

1. Opposition by the railroads to the installation of automatic train control is not a question of balancing money against human lives, but of saving the greatest possible number of lives with the money available.

2. Automatic train control devices are in an experimental stage, and anything beyond experimental installation is a waste of money.

3. General installation of automatic train control, as ordered by the Interstate Commerce Commission, would seriously reduce the carrying capacity of existing railroad lines.

In its decision, dated July 18th but only recently made public, the Interstate Commerce Commission has to a considerable extent recognized the validity of the case presented by the railroads.

Not Opposed to Principle

With reference to the general position of the railroads on the question the Commission says:

"Respondents assert generally that they are not opposed to the principle of automatic train control, but that the devices which they would not feel constrained to select for installation are in the development stage as far as the apparatus is concerned, and still in the experimental stage from the standpoint of adaptation to railroad operating conditions."

Development Has Been Slow

With reference to the contention that automatic train control is still in the experimental stage the Commission says:

"The carriers claim that undesirable features exist in all the devices. The discovery and elimination of undesirable features has not proceeded as rapidly as we had reason to expect."

With reference to the contention of the railroads that the failure to leave control of the locomotive in the hands of the engineer would seriously reduce the carrying capacity of existing lines, the Commission says:

"The matter of providing for the permissive feature in automatic train-stop devices was considered in our original report. While there was testimony in that case both in favor of and against the permissive feature, it was inconclusive. At the hearing in this case the testimony was overwhelmingly in favor of the permissive feature. Operating men almost without exception favored the adoption of such a feature and expressed the opinion that it was sufficient to require the engineman to take some affirmative action to indicate that he is alert. The chief operating officer of the Rock Island and one of the locomotive engineers from that road who appeared as witnesses for the train control companies favor the use of the permissive feature. Certain carrier officials recognize the possibility that this feature might lead to carelessness, but believe that it should be left to the judgment of the management of a road to decide whether a permissive feature should be employed under certain operating conditions.

"The Chicago & Eastern Illinois and the Chesapeake & Ohio, both use the permissive feature and no instance has developed where safety has been adversely affected thereby. Both of these companies favor its continued use.

"We are of the opinion that the evidence now before us warrants a modification of our former conclusion with respect to this permissive feature, although we shall continue to keep this matter under close observation."

Further Tests to Be Made

In conclusion the Commission accepted a proposal of the carriers for a joint committee to conduct further tests; and postponed indefinitely the application of its second order of January 14, 1924, requiring 42 additional roads to install automatic train control on one division on or before February 1, 1926.

This action leaves still standing the Commission's original order of June 13, 1922, requiring 49 roads to complete installation of automatic train control over one division by January 1, 1925, and 47 of the above to complete installation on an additional division by February 1, 1926, but these installations may now leave control of the locomotive in the hands of the engineer.

17,926 New Cars and 197 Locomotives Installed in July

Class 1 railroads during the month of July installed 17,926 freight cars, according to reports filed by the carriers with the Car Service Division of the American Railway Association.

This brought to 88,800 the total number of freight cars placed in service during the first seven months this year which was a decrease, however, of 8,150 compared with the number installed during the first seven months in 1923.

Of the 17,926 installed in July, box cars totaled 7,179, coal cars 5,121 and refrigerator cars 2,770, including those of both railroad and railroad owned private refrigerator companies.

Reports showed 52,375 freight cars on order and awaiting delivery on August 1st compared with 86,716 on August 1, 1923.

Class I railroads also placed in service 197 locomotives during the month of July which brought the total installed from January 1st to August 1, 1924, to 1,268. During the first seven months in 1923 the railroads installed 2,221 locomotives or an increase of 953 compared with the corresponding period this year.

Locomotives on order on August 1st totaled 401 compared with 1,772 on order on the same date last year.

These figures, both for freight cars and locomotives, include new, rebuilt and leased equipment.

Equipment Prices Have Practically Doubled Since 1910

The cost of equipment has doubled since the pre-war period. The price of equipment was higher in 1923 than in 1921 and 1922 but not as high as was reached in the peak of 1920.

On a base of the average prices from 1910 to 1914 as

100 the indices of equipment prices in 1923 were shown to be as follows:

Index Numbers of Equipment Prices in 1923, Compared With the 1910-1914 Average

Locomotives	224
Passenger train cars	194
All-steel freight cars	203
Freight cars of composite construction	209
All wood freight cars	201

These prices and the indices are figured on a per pound basis of the simple or standard locomotive or car and do not include the specialties; in other words, they do not reflect the increase in size of equipment in the period which has been covered.

This information has been prepared by the equipment committee of the presidents' conference committee on federal valuation which prepared studies of the cost of locomotives, freight cars and passenger cars for valuation purposes some years ago.

The trend of average equipment prices for the period 1910 to 1923 was worked out by the equipment committee in cooperation with certain of the equipment builders. The weighted average price per pound as sold for the period 1910-1914, inclusive, has been taken as the base, or 100 per cent for each class of equipment.

National Exposition of Power and Mechanical Engineering

The third annual exposition of the National Exposition of Power and Mechanical Engineering will be held in the Grand Central Palace, New York, December 1 through 6, 1924, and will parallel the annual meetings of the American Society of Mechanical Engineers and the American Society of Refrigerating Engineers. The coming show has twice the requests for space that the previous show had at a corresponding time last year, and the attendance last year increased 30 per cent over that of the year before. The managers of the Exposition are Fred W. Payne and Charles F. Roth, whose headquarters are in the Grand Central Palace, New York, N. Y.

46.8 Per Cent of Locomotives Found Defective

Of 5,460 locomotives inspected by the Bureau of Locomotive Inspection during July, 2,553 or 46.8 per cent were found defective and 282 were ordered out of service, according to the Interstate Commerce Commission's monthly report to the President on the condition of equipment. During the first six months of 1924, of 34,174 locomotives inspected, 17,482 or 51 per cent were found defective and 2,842 were ordered out of service. Of 95,047 freight cars inspected by the Bureau of Safety during July, 3,692 or 3.9 per cent were found defective and of 2,162 passenger cars 25 were found defective. During the month 40 cases, involving 123 violations of the Safety Appliance Acts, were transmitted to various United States attorneys for prosecution.

Surplus Freight Cars Show Gradual Reduction

Due to the seasonal increase in demand for transportation facilities, a gradual reduction in number of surplus freight cars in good repair and immediately available for use is being reported by the railroads of the United States. Surplus freight cars on August 15, according to reports filed today by the carriers with the car service division of the American Railway Association, totaled 278,476, a decrease of 18,020 compared with the number reported on August 7, at which time there were 296,496. Surplus coal cars in good repair on August 14 totaled 127,801, a decrease of 10,524 under the number reported on August 7 while surplus box cars in good repair totaled 171,111, a decrease of 6,233 within a week. Reports showed 13,372 surplus stock cars, a decrease of 1,239 since August 7, while there was a decrease during the same period of 42 in the number of surplus refrigerator cars, which brought the total for that class of equipment to 10,907. Virtually no car shortage is being reported.

Notes on Domestic Railroads

Locomotives

The Alabama & Vicksburg Railway has ordered 2 Mikado type locomotives from the Baldwin Locomotive Works.

The Natchez, Columbia & Mobile Railroad has ordered one Mikado type locomotive from the American Locomotive Company.

The Illinois Central Railroad is inquiring for 25 Mountain type locomotives.

The F. C. Al Pacifico of Costa Rica has ordered 2 Mogul type locomotives from the Baldwin Locomotive Works.

The Detroit Edison Company has ordered one switching type locomotive from the Baldwin Locomotive Works.

The Shafer Brothers Logging Company has ordered one Prairie type locomotive from the Baldwin Locomotive Works.

The Detroit Terminal is inquiring for 2, 0-8-0 switching type locomotives.

The F. C. de Huancayo a Ayacucho, Peru, has ordered one Mogul type locomotive from the Baldwin Locomotive Works.

The Green Bay & Western Railroad has ordered a 2-6-0 type locomotive from the American Locomotive Company.

The Northern Pacific Terminal has ordered one locomotive from the American Locomotive Company.

The Pacific Gas & Electric Co., San Francisco, Calif., has ordered one 70-ton Shay geared locomotive from the Lima Locomotive Works.

The Paulista de Estrados de Ferro, Brazil, has ordered 4 Mikado type locomotives from the Baldwin Locomotive Works.

Freight Cars

The Chesapeake & Ohio Railway has ordered 987, 70-ton hopper bottom gondola car bodies from the American Car & Foundry Company, 1,000 from the Richmond Car Works.

The General Sugar Company has purchased for export from the Magor Car Company, 70, 15-ton cane cars, for the Central Sansidro Railroad.

The St. Louis Southwestern Railroad is inquiring for 1,000 box cars.

The American Refrigerator Transit Co. has placed an order covering repairs of 700 refrigerator cars with the Sheffield Car & Equipment Company.

The Northern Pacific Railway is inquiring for 15 underframes.

The Minneapolis, St. Paul & Sault Ste. Marie Railway is inquiring for 25 caboose underframes.

The Carnegie Steel Co. has placed an order for 2, 70-ton flat cars and one 70-ton gondola car with the Canton Car Company.

The Swift & Company has ordered 200 underframes from the Western Steel Car & Foundry Company.

The Pere Marquette Railway is inquiring for 34 caboose underframes.

The Texas & Pacific Railway is inquiring for 1,000 double-sheathed automobile box cars and 1,000 automobile cars either single or double sheathed.

The United States Rubber Company has ordered 10 tank cars of 8,000 gal. capacity from the American Car & Foundry Company.

The Barndall Refining Company has ordered 50 tank cars of 8,000 gal. capacity from the Pennsylvania Car Company.

The Chicago, Rock Island & Pacific Railway has placed an order with the Pressed Steel Car Company covering repairs to 250 refrigerator car bodies.

The Missouri Pacific is inquiring for 50 caboose cars.

The Chesapeake & Ohio has given a contract to the Richmond Car Works for equipping 1,000, 70-ton hopper bottom gondola cars with new bodies.

The Pennsylvania's orders placed last week for 10,000 new, all-steel box cars were divided equally between the American Car & Foundry Co., the Pressed Steel Car Company, the Standard Steel Car Company and the Bethlehem Steel Company, for delivery at an early date.

The Chicago, Indianapolis & Louisville Railway is inquiring for 250 underframe construction.

The Western Fruit Express Co. has placed an order with the Ryan Car Company for 550 underframes, and with the Bethlehem Steel Co. for 100 underframes.

The Swift & Company, Chicago, Ill., has placed an order with the Pressed Steel Car Company for 200 underframes.

The Missouri Pacific Railroad and its subsidiary have placed orders for the following cars as follows: 725 refrigerator cars and 250 automobile cars with the American Car & Foundry Company, 725 refrigerator cars with the Mt. Vernon Car & Mfg. Co., 500 refrigerator cars and 375 automobile cars with the General American Car Company, and 375 automobile cars with the Standard Tank Car Co.

The Pacific Fruit Express is inquiring for 1,000 underframes.

The Quaker City Tank Line, St. Louis, Mo., has placed a contract with the Standard Tank Car Company, covering the building of 125, 8,050-gal. tank cars, also 75, 10,050-gal. coiled tank cars.

The Union Railroad is inquiring for 12 gondola cars of 70-ton capacity.

The National Refining Company, Cleveland, Ohio, has ordered 16 tank cars from the Standard Tank Car Company.

The Tri-State Refining Co., Huntington, W. Va., has placed an order for 6, 8,050-gal. tank cars with the Standard Tank Car Company.

The Seaboard Air Line Railway has ordered 10 caboose cars from the American Car & Foundry Company.

The Caloric Company, New York City, is inquiring for 10 tank cars of 7,000-gal. capacity.

Passenger Cars

The Minneapolis, St. Paul & Sault St. Marie Railway has ordered 4 coaches and 2 baggage-mail cars from the Pullman Company.

The Indiana Traction Company has ordered 15 passenger cars from the St. Louis Car Company.

The Gulf Coast Lines are inquiring for 2 all-steel diners.

The Seaboard Air Line Railway has placed orders for 6 express cars, 6 passenger-baggage cars and 6 baggage-mail cars with the American Car & Foundry Company.

The Lehigh Valley Railroad is inquiring for 5 coaches.

The Wilmington, Brunswick & Southern Railroad has placed an order with the Edwards Railway Motor Car Co. for one gasoline motor car and trailer, with an 18-ft. baggage compartment.

The Illinois Central Railroad is inquiring for 200 express-refrigerator cars.

The Baltimore & Ohio Railroad has placed an order with the Standard Steel Car Co. for 80 suburban coaches, to be used on the Staten Island Railroad.

The Great Northern Railway has placed an order for 50 express-refrigerator underframes with the Siemms-Stemble Co., St. Paul, Minn.

The New York Central Railroad is inquiring for one passenger mail car for the Rutland Railroad.

The Missouri Pacific Railroad is inquiring for 50 express-refrigerator cars.

The Interborough Rapid Transit Company will buy 150 subway cars, through the Rapid Transit Subway Construction Company.

Buildings and Structures

The Pennsylvania Railroad is reported to be planning the construction of a 29-stall enginehouse at East Toledo, Ohio, to cost approximately $500,000.

The Central Railroad of New Jersey plans the construction of an enginehouse and locomotive repair shops at Bethlehem, Pa.

The Boston & Maine Railroad has authorized improvements to its engine terminal at Springfield, Mass., to cost approximately $44,000.

The Delaware, Lackawanna & Western Railroad has placed a general contract with F. D. Hyde, New York City, covering the construction of an engine house, repair shops and yards at Binghamton, New York.

The New York, Chicago & St. Louis Railway has awarded a contract to the Erie Steel Construction Company covering repairs to its shops at Conneaut, Ohio.

The New York Central Railroad has awarded a contract to the Austin Company covering the construction of a steel frame, brick repair shop at Hammond, Ind., one-story, 90 by 130, to cost approximately $40,000.

The Union Tank Car Company has awarded a general contract covering the construction of a car repair shop in Philadelphia, to cost approximately $130,000.

The Cleveland, Cincinnati, Chicago & St. Louis Railway has awarded a general contract covering the erection of an addition to its roundhouse and shops at Sharonville, Ohio, to cost approximately $90,000.

The Atchison, Topeka & Santa Fe Railway has awarded a contract for the construction of a one-story shop building at Topeka, Kan., to cost approximately $40,000.

The Canadian National Railways closed bids for the construction of three-stall brick addition to its roundhouse at Brandon, Sask.

The Chicago, Rock Island & Pacific Railway is receiving bids for the construction of extensions to the stalls of its roundhouse at Cedar Rapids, Iowa.

The Chesapeake & Ohio Railway plan the construction of shops at Richmond, Va., estimated to cost between $2,000,000 and $3,000,000.

The Western Pacific Railroad plans the construction of a concrete roundhouse and machine shop at Stockton, Calif.

The Southern Railway has placed a contract with the Foundation Co., covering the erection of a new locomotive repair shop at Atlanta, Ga., to be 325 by 300 steel, with brick walls.

The Missouri Pacific Railroad has awarded a contract for the construction of a machine shop at Fort Scott, Kansas.

The Chicago Rock Island & Pacific Railway plans to rebuild its shops at Shawnee, Okla., which were recently damaged by fire. Repairs are to cost approximately $60,000.

The Sioux City Terminal Co. has awarded a contract covering the construction of a one-story machine and repair shop, 100 by 150, to cost approximately $100,000, including equipment.

The Northern Pacific Railway is constructing a brick boiler and tank shop at Livingston, Mont.

The Texas & Pacific Railway plans the construction of an engine house repair shop and sheds at Dallas, Texas.

The Southern Railway, it is reported, will install a modern foundry at its shops at South Richmond, Va., at an estimated cost of $46,000.

Items of Personal Interest

Frank J. Regan has been appointed fuel supervisor of Northern Pacific Railway, with headquarters at Duluth, Minn., succeeding **Melvin Montgomery**, who died August 8, 1923.

G. S. West, general foreman of the Cumberland division of the Pennsylvania Railroad, has been appointed assistant master mechanic of the Meadow shops, New York division, succeeding **J. A. Sheedy**, promoted.

C. A. Hodgman, assistant superintendent of the Minneapolis & St. Louis Railroad, with headquarters at Oskaloosa, Iowa, has been promoted to superintendent of the Central division, with headquarters at Fort Dodge, Iowa, succeeding **J. H. Reinholdt**, resigned.

L. L. Trout has been appointed superintendent of motive power on the Uintah Railway, with headquarters at Atchee, Colo.

G. H. Walker, of New York City, has been elected chairman of the board and chairman of the executive committee of the International Great Northern Railroad.

P. A. Carter, foreman of the Chouteau Avenue shops, of the St. Louis-San Francisco Railway, with headquarters at St. Louis, Mo., has been promoted to roundhouse foreman of the new Lindenwood shops, at St. Louis, Mo.

William O. Forman has been made mechanical superintendent of the Boston & Maine Railroad, succeeding **Charles H. Wiggin**, who has been made consulting mechanical engineer, with headquarters at Boston, Mass.

W. D. Lyons has been appointed erecting shop foreman of the Illinois Central Railroad, with headquarters at McComb, Miss., and **A. D. Haley** becomes night foreman at the same point.

L. H. Petrot has been appointed assistant superintendent of the Toledo division of the New York Central Railroad, succeeding **C. M. Williams**, promoted.

R. B. Mann, present superintendent, Akron division of the Baltimore & Ohio Railroad, with headquarters at Akron, Ohio, succeeds **Mr. Brooks** as superintendent of transportation, with headquarters at Cincinnati, Ohio. **S. U. Hooper**, present superintendent, Chicago division, with headquarters at Garrett, Ind., succeeds **R. B. Mann**. **H. G. Kruse**, present superintendent, Newark division of the Baltimore & Ohio Railroad, with headquarters at Newark, Ohio, succeeds **S. U. Hooper** as superintendent of the Chicago division, with headquarters at Garrett, Ind. **J. E. Fahy**, present assistant superintendent of the Akron division succeeds **H. G. Kruse** as superintendent of the Newark division, with headquarters at Newark, Ohio.

W. J. Ficke, formerly night general foreman of the North Side shops of the St. Louis-San Francisco Railway, with headquarters at Springfield, Mo., has been appointed general foreman of the new Lindenwood shop at St. Louis, Mo.

W. C. Beck, formerly chief clerk to the first vice-president of the Canadian Pacific Railway, has been appointed assistant superintendent of the Ottawa division, with headquarters at Ottawa, Ont., Canada.

P. T. Curley has been appointed blacksmith foreman of the Illinois Central Railroad, with headquarters at East St. Louis, Ill., succeeding **Wm. Kirkwood**, retired.

Robert H. Hunter has been appointed mechanical examiner and instructor of enginemen on the Oregon Short Line Railroad, with headquarters at Pocatello, Idaho.

Frank E. Strouse has been appointed special representative of the vice-president of the Pennsylvania Railroad, with headquarters at St. Louis, Mo.

H. O. Kelley, division engineer of the Peru division of the Wabash Railway, with headquarters at Peru, Ind., has been appointed general manager of the Toledo & Western Railroad, with headquarters at Sylvania, Ohio, succeeding **A. Swartz**, who has resigned.

D. K. Chase, motive power inspector of the Meadow shops, New York division of the Pennsylvania Railroad, has been appointed general foreman of the Cumberland division, succeeding **G. S. West**.

William N. Neff has been promoted to superintendent of the Pueblo division of the Denver & Rio Grande Western Railroad, with headquarters at Pueblo, Colo., to succeed **C. E. Leverich**, resigned.

E. Posson, engineer of car construction of the Atchison, Topeka & Santa Fe Railway, with headquarters at Chicago, Ill., has retired.

Supply Trade Notes

The Worthington Pump & Machinery Corp. has awarded a contract to the **Austin Company**, Cleveland, for a new unit of its Buffalo plant at Buffalo, New York.

A. C. Irwin has been appointed manager of the railway bureau of the **Portland Cement Association**, with headquarters at 111 West Washington St., Chicago, Ill., succeeding **D. A. Tomlinson**, who died on August 7.

Theodore B. Counselman has been appointed western representative of the **Clark Car Company**, Pittsburgh, Pa., with headquarters at 122 South Michigan Avenue, Chicago, Ill.

H. P. Anderson has been appointed mechanical engineer of the **Standard Stoker Company, Inc.**, with headquarters at Erie, Pa.

L. G. Coleman has resigned as assistant general manager of the Boston & Maine Railroad to become manager of the locomotive department of the **Ingersoll-Rand Company**, New York. This department was organized to handle the oil electric locomotive. **W. L. Garrison** has been appointed assistant manager of the same department.

The Linde Air Products Co. plans the construction of a plant at Houston, Texas.

Albert Swartz, formerly general manager of the Toledo & Western Railway, has been appointed district sales agent of the **Arcco Anti-Rail Creeping Company** of Oswego, New York, with offices at 1526 Manhattan Building, Chicago, Ill.

T. E. Murphy, assistant manager of industrial sales of **Pratt & Lambert, Inc.**, Buffalo, New York, has been appointed manager of industrial sales.

J. H. Hageman, general manager of the Bement plant of the **Niles-Bement-Pond Co.**, Philadelphia, Pa., has resigned.

The Appleton Train Control Company, 108 South LaSalle Street, Chicago, Ill., has been incorporated with a capital of $20,000. **Russell V. Appleton, Arch Welty** and **William C. Ratner** are the incorporators.

Joseph J. Root has been appointed assistant to the vice-president of the **Union Tank Car Co.**, New York, N. Y.

W. G. Martin has been appointed sales manager of the **Landis Tool Company**, Waynesboro, Pa., succeeding **H. T. King**, resigned.

The Bethlehem Steel Co. plans the construction of a $200,000 concrete and steel power plant at Johnstown, Pa.

F. A. Keihn, formerly of the engineering department of the **International Motor Company**, has been appointed sales engineer of the automotive car division of the **J. G. Brill Co.**, Philadelphia, Pa.

F. M. English has been appointed assistant sales manager of the **Reading Iron Company**, with headquarters at Reading, Pa., succeeding **A. F. Clintock**, resigned.

The Falls Hallow Staybolt Company, Cuyahoga Falls, Ohio, has appointed the **Tabson Company** as its special representative in Illinois, with offices in the Railway Exchange Building, Chicago, Ill.

D. M. French, mechanical engineer of the **Gill Railway Supply Company**, with headquarters at Peoria, Ill., has been transferred to Chicago, Ill.

George C. Billman has been elected president of the **Charles C. Young Manufacturing Company**, Jersey Shore, Pa.

The Whiting Corp., Harvey, Ill., plans the construction of a power house one-story and basement, estimated to cost $40,000.

The Transportation Devices Corporation, Indianapolis, Ind., has appointed the **Lyman Tube & Supply Company, Ltd.**, Montreal, as its Canadian representative. This company are manufacturers of automatic cut-off control for locomotives.

The Southern Wheel Company, St. Louis, Mo., will enlarge its branch plant at Nevada, Ga.

The plant of the **American Car & Foundry Co.**, Buffalo, New York, was struck by lightning and damaged by fire recently.

Thomas H. King has been appointed treasurer and manager of the **Wayne Tool Mfg. Co.**, Waynesboro, Pa., maker of reamers for railway car manufacture, bridge work, etc. **Mr. King** was previously connected with the sales department of the **Landis Tool Company**, Waynesboro, Pa.

The Chicago Pneumatic Tool Co. announces the transfer of **Ross Watson**, formerly district manager of the Cleveland branch office to district managership of the Minneapolis branch to succeed **D. M. Wesbrook**, now general manager of the Canadian Pneumatic Tool Co.

D. R. Arnold, formerly sales manager of the **Canadian Car & Foundry Co.**, Montreal, Canada, has resigned to become vice-president of the **United Metal Products Co.**, with headquarters at 20 West Jackson Blvd., Chicago, Ill.

George Hush, Jr., has become associated with machine tool sale department of **Joseph T. Ryerson & Son**, Buffalo, New York.

W. L. Loegler has been appointed representative of the **Warner & Swasey Company**, Cleveland, O., with headquarters at Philadelphia, Pa.

The Jones & Laughlin Steel Company, Pittsburgh, Pa., has moved its San Francisco, Calif., offices from the Crocker Bank Building to Standard Oil Building.

The plant of **Robert M. Lucas Co.**, Chicago, Ill., manufacturer of car cement and waterproofing, was badly damaged by fire recently.

David E. Drake, dean of the Sales Department of the **Westinghouse Electric & Mfg. Co.**, over 50 years in the electrical industry and 34 years with this company, retired today. He will make his future home at San Diego, Cal.

A luncheon was tendered Mr. Drake by the officials and members of the sales department of the Westinghouse Company at the Railroad Club at noon today. During the luncheon Mr. Drake was presented with a purse of gold and speeches were made by E. M. Herr, President of Westinghouse Electric & Mfg. Co.; Loyal A. Osborne, President of Westinghouse International Co., and other officials of the company, many of whom were associated with Mr. Drake in the early days of the industry.

The Transportation Devices Corporation, Indianapolis, Ind., which is placing automatic cut-off control on many locomotives in the U. S., recently appointed the **Lyman Tube & Supply Company, Ltd.**, of Montreal, as Canadian representatives. This company has branch offices in Toronto and Vancouver. Canadian railways are showing much interest in the automatic cut-off control.

Obituary

E. J. Chamberlin, formerly president of the Grand Trunk Ry., Grand Trunk Pacific Ry., and the Central Vermont Ry., died at Pasadena, Cal., on August 27. Mr. Chamberlin was born in Lancaster, N. H., on August 25, 1852, and was educated at the Montpelier Methodist Seminary. He entered railway service in 1871 as timekeeper in the car shops of the Vermont Ry., at St. Albans, N. Y. From 1872, to 1875, he was clerk in the paymaster's office and the office of the superintendent of transportation. From 1875 to 1876, he was corresponding secretary for the general superintendent, and from 1877 to 1884, private secretary to the general manager. In April, 1884, Mr. Chamberlin was appointed superintendent of the Ogdensburg & Lake Champlain R. R. and the Central Vermont line steamers, and on September 1, 1886, he was appointed general manager of the Canadian Atlantic Ry. From October 1, 1905 to 1908, he engaged in railway contracting in Canada, South America and Mexico, returning to railway service in 1909 as vice-president and general manager of the Grand Trunk Pacific Ry., with headquarters at Winnipeg, Man. In May, 1912, he was appointed president of the Grand Trunk and Grand Trunk Pacific Rys., and on January 23, 1913, also president of the Central Vermont Ry. Mr. Chamberlin retired as president of these lines on September 1, 1917.

New Publications

Books. Bulletins, Catalogues, Etc.

The Influence of the Valve Motion upon the Efficiency, Steam and Coal Consumption of Superheated Steam Locomotives, by G. Strahl: 106 pages with 36 illustrations, bound. Hanomag Intelligence Press, Hannover-Linden, Germany.

The application of a uniform size of piston valve for the different sizes of cylinders in superheated steam locomotives of the earlier Prussian State Railway locomotives gave rise to the investigation of the question, as to what influence the valve gear, and upon it the ratio of expansion of the steam admitted would exert upon the steam and coal consumption. First of all, the author takes up the dependence of the ratio of expansion upon the valve gearing, the dimensions of the piston valves, the cylinders and the calculation of the tractive effort, as well as the mean effective cylinder pressure and finally the efficiency and the hourly steam consumption, both on the basis of the cylinder capacity of a two-cylinder superheated steam locomotive.

The exposition of the steam consumption as developed as a function of the tractive effort developed is of especial value. The resultant curve as developed by von Strahl, which is called the "Working Characteristic," shows the characteristics that belong to a single expansion of the steam in a cylinder of the ordinary size for the usual tractive effort, also pertains to all superheated steam locomotives with a single piston valve.

In order to demonstrate the above statements, a comparison is made of the steam consumption of two superheated steam freight locomotives, showing the working characteristic in relation to the work done and distance run, in which the steam consumption figures were kept at their lowest average points during the experimental runs, and were based both on the horsepower developed and the hourly consumption, and showed also that the steam consumption obtained lay within the limits of observation.

In the same manner, it is shown to be a matter of importance, as far as coal consumption is concerned, if one is looking to the work alone to determine whether a locomotive under a given set of working conditions is properly loaded.

The author also shows how similar determinations can be made for compound locomotives with corresponding changes.

Locomotive Feed Water Heaters: The Superheater Company of New York and Chicago has just issued a series of three interesting folders on locomotive feed water heating. On folder A are diagrams illustrating through colors the variour passages of steam and water, as well as the principle of utilizing waste heat for pre-heating boiler feed water through the meduim of the Elesco Non-Contact Feed Water Heater. Folders B and C discuss in concise form the advantages of heating boiler feed water and the special advantages claimed for the Elesco heater. There are also illustrations of the units of the equipment and various installations.

The chart shown on folder A is a fac-simile of the chart recently issued by The Superheater Company. This chart is printed on stiff stock, size 20 x 43½" and is suitable for framing for roundhouses and railroad offices.

Copies of this chart or the folders will be sent upon application to anyone mentioning this publication.

Electric Equipment for Railroad Shops, is the title of a new publication that is being distributed by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. The publication is known as C-1661 and is intended to assist engineers in solving the electrical problems frequently encountered in increasing shop facilities or changing or adding to existing equipment. It contains pertinent information and general principles, serving as a guide in the selection of electrical equipment for engine and car shops, engine terminals, freight terminals and passenger stations. The results of the application of individual motor drive and the extensive use made of magnetic control, both automatic and semi-automatic, in railway shops are described in detail and by illustrations. A description of the arc welding process and its uses in track reclamation, general track repair work, together with valuable machine tool data, are included within its pages.

The American Engineering Standards Committee has issued a booklet on the progress that has been made in standardization. The booklet points out three worthy stages of standardization within the factory; within the industry and national standardization. It shows some of the more important standardization work of the Government, and the efforts of all these separated interests, the formation of the American Engineering Standards Committee.

The members of this committee are nine national engineering societies, seven departments of the Government and nineteen national associations representing most of the industries of the country.

Those interested in this important question may have a copy of this interesting booklet by addressing the Committee, 29 West 39th Street, New York City.

Electric Fans for Blowing, Exhausting, Ventilating, Cooling and Drying, is the title of a 16-page booklet which is an exceptionally comprehensive review of the application of electric fans just issued by the Buffalo Forge Co., Buffalo, N. Y. The subject matter is confined solely to direct connected units, including descriptions of small disk or propeller fans, multiblade type fans used for heating and ventilating, stoker units, pressure blowers, mill exhausters and electric forge blowers. The booklet is amply illustrated with views of installations in various types of industrial plants and should be of value to the executive and factory management interested in the advantages of motor driven blowers and exhaust fans.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XXXVII — 114 Liberty Street, New York, October, 1924 — No. 10

The Bay Shore Shops of Southern Pacific Company Near San Francisco, California

Some of the Details of Arrangement and Special Appliances in Use

The planing mill and car repair building of the Southern Pacific Company at their Bay Shore Shops is a steel frame and brick structure 185 feet by 333.5 feet. A space 66 feet by 185 feet on the west end of this building is devoted to the planing mill. The floor of the planing mill section is of wood and that of the car repair building is of concrete, the roof being of the gravel and tar kind.

The east end of the car repair building is occupied by the paint and varnish stock-room and the upholstering department. These departments are separated from the main coach shop by a glass partition.

The upholstering department cleans and makes all repairs to all kinds of seats, chairs, window curtains and also all of the many other items connected therewith.

There is a special mezzanine floor which is equipped with a steam vulcanizing table for vulcanizing the various rubber articles such as aisle strips and platform rubber. There is also an electrically operated sewing machine for sewing carpets and canvass and leather goods.

Bay Shore Shops of Southern Pacific Company Showing Racks for Storing Parts Removed from Locomotives Undergoing Repairs

The car repair department is engaged in making repairs and in the general overhauling of all classes of passenger equipment.

There are twelve tracks in the coach shop and one in the mill room. There is a space of twelve feet between each track which is ample for making repairs.

An unusual number of skylights and windows in the building provides ample lighting. There are 30 skylights on each side of the coach shop. All doors are double swinging doors, and are easily operated. Each door has a window in the upper half, and above each door there is a window with three sections of glass.

A fire wall separates the coach shop from the mill room, where all of the mill work on the freight and passenger equipment is done. This includes such work as framing sills, end plates, side plates, truck bolsters, as well as surfacing all lumber necessary for the passenger equipment. A special building serves as a store room for storing all lumber for the car repair department for both freight and passenger cars, and a very large quantity at all times. That commonly carried being Oregon fir, poplar, ash and mahogany, in many lengths and sizes.

A section of the mill room is occupied by the wheel presses with a track extending entirely through that department as well as the mill room which serves for the delivery of the wheels to the presses and their removal from the same.

A portion of the west end of the coach shop is occupied by the air break testing plant. This section of the shop is also equipped with sketches and air brakes for teaching and demonstrating the operation of the air brakes which are now used on the Southern Pacific lines. All triple valves removed are delivered to this department where they are repaired and tested and made ready for further service. Those that cannot be repaired are turned over to the Westinghouse Air Brake Company plant at Emeryville, California. All car inspectors of the coast division are required to take air brake examinations from an expert air brake man. In addition to the sketches and charts of air brakes, triple valves are provided which are cut away in such a manner that all working parts can be seen while the brakes are under operation.

The metal polish department is also located in this section of the shop, as well as the sheet metal workshop. This department repairs and manufactures stove pipe and various other items such as oil cans and similar articles. Steel ranges and stoves for dining cars are also rebuilt in this department, which also looks after all steam and water pipes and does all the soldering necessary on freight and passenger equipment.

Immediately to the north of the planing mill and car repair building is the freight car repair shed. This is a steel frame structure 117 by 441 feet and is open on all sides except that on the west which is covered with galvanized corrugated iron as a protection against the high prevailing winds.

Here all steel cars, including tank cars, requiring heavy repairs are handled. About 15 per cent of the cars passing through this department are tank cars, the other 85 per cent being the general run of freight cars, such as box, stock, hopper, gondola and flat cars.

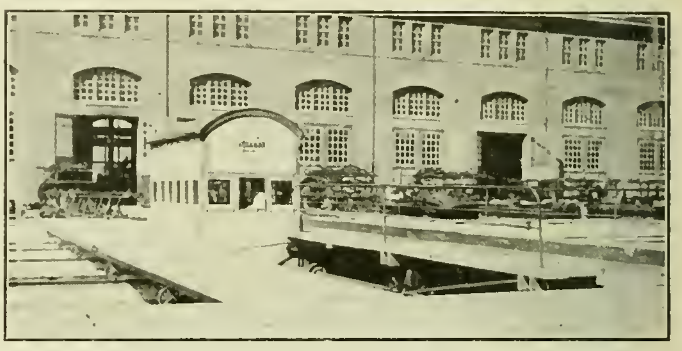
There are five tracks under the freight car repair shed holding eleven cars each and one track on the west side of the shed which is used as a storage track for cripple and bad order cars, this track having accommodations for 35 cars. Tank cars are steam cleaned and water tested on this track before being taken into the repair shop.

On the east side of the freight car repair shed is the cripple yard with thirteen tracks having a total capacity of 250 freight cars. Each of these tracks has a bulkhead to prevent the cars from being shoved across the roadway between the end of the tracks and the coach shop building. This roadway is essential for material delivery and it must be kept clear at all times so as to enable fire fighting equipment to pass. It is lighted at night by electric lights supported from the side of the building.

The freight car repair shop and the cripple yards are well supplied with modern pneumatic tools, including air riveters and hammers, bolt cutters and chipping and calking tools. A two inch air line serves this section of the shops, there being eleven air tanks located at various points for supplying air. By having these tanks located at various points a much better supply of air is provided than would be the case if only one large tank was used.

Near the car repair section there are a large number of "A" frames and racks which are used each season to convert 250 flat cars into sugar-beet cars, which are used each year at various points on the coast division. The work of converting the flat cars begins in the early part of June and they are dismantled in February after the beet season is over. Most of the "A" frames and racks were constructed at the Bay Shore shops. They are built of Oregon fir and are designed to carry 50 tons of beets. A steam crane with specially made equalizer and chain sling on each end is used in handling them. The special equalizer and spring makes it possible to do this without damaging them.

In the forge shop there is equipment for making all kinds of repairs on locomotives. While the department is not equipped to make new frames complete, they can make sections of frames which are taken to the engine and welded on.



Southern Pacific Company's Bay Shore Shops—Transfer Table in Foreground

There are two forging furnaces, both being oil burners, which were built in the shop by the shop foreman from scrap. One is 68 in. by 32 in. by 30 in. The other is 7 ft. long, 4 ft. wide and 3 ft. 6 in. high.

A case hardening furnace and a tool steel hardening furnace were also made from scrap iron. The former is 7 ft. long, 2 ft. 6 in. wide and 2 ft. high. The tool steel hardening furnace is 33 in. by 34 in. This is a special furnace and is used principally in hardening and tempering high speed carbon and tool steel, many of the tools being made in the shop.

There are two self supporting cranes in the center of the forge shop, each crane being of four tons capacity, one serving the large furnace and the other serving the heavy fire. There is one wall crane which serves the small forging furnace.

There are eleven coal forges, each being circular in shape and four feet in diameter, all but one resting directly on the ground.

There is a No. 8 fan for the forges, with the main supply pipe 12 inches in diameter which is carried overhead across the shop, and which drops from the line down to each forge. These drops are 3½ inches in diameter, with the exception of those leading to the furnaces, which are 4 inches in diameter. The forges and furnaces have connection with the compressed air line, which is used in case of an emergency.

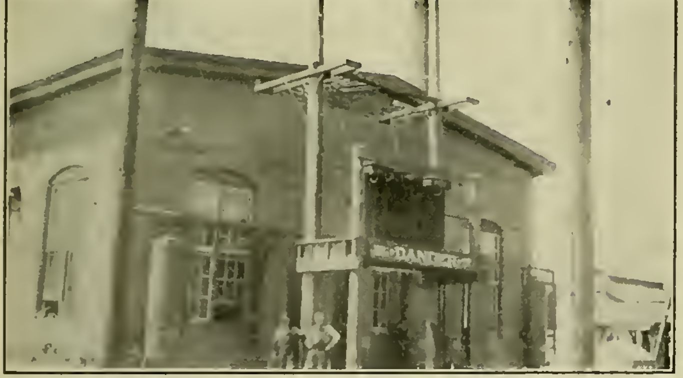
The forge shop is unusually airy, roomy and well lighted and ventilated, there being a very efficient system which removes most of the smoke and gases. There is a track leading to the shop, and by means of this the locomotive cranes are enabled to bring in heavy forgings.

The oil to the oil burners in the forge department is supplied by means of a steam driven compound plunger pump, drawing oil from an underground storage tank of 1,000 gallons capacity. The pump discharges into a 2-inch pipe system extending throughout the department. The oil is heated to the proper temperature by means of a system of steam coils; exhaust steam from the pump passing through the coils and heating the oil as it circulates around them. The oil is then delivered to the burners at a pressure of about 80 lbs. per sq. in. where it is atomized by compressed air at a pressure of 90 lbs. per sq. in.

There is a transfer pit which extends between the erecting shop and the round house and the boiler shop. This pit is 490 feet in length, and provides a quick means of transferring both locomotives and boilers from the erecting shop to and from the boiler shop, and for transferring locomotives from the erecting shop to the round house.

A novel feature of this pit is the transfer table trailer. This trailer was built to enable hand trucks to be taken across the pit between the erecting shop and the boiler shop. It is seldom necessary to move the trailer, the only time being when the transfer table is to be moved to the extreme west end of the pit. In this case the transfer table is used to push the trailer out of the way, and it is again towed back to place when the transfer table is again moved toward the other end of the pit. This trailer is built in three sections and can be quickly and easily attached to the transfer table when it is desired that it be moved.

Among the conveniences in use about the shops there are some special storage racks located between the tracks



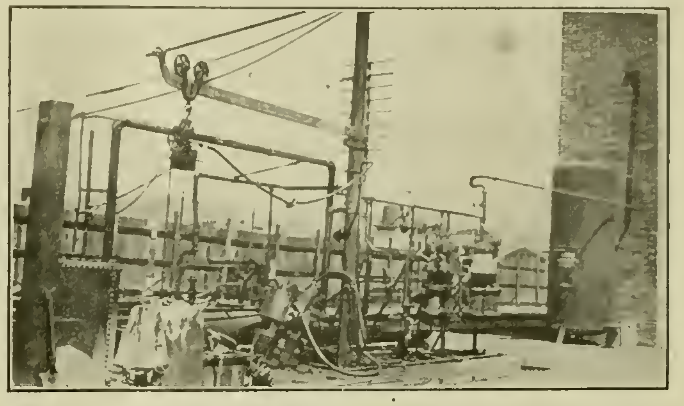
Small Compressed Air Supply Tanks That Are Used at the Southern Pacific Shops

outside of the erecting shop, and which are used for storing the parts of stripped engines that are undergoing repairs. They are constructed of scrap flues and are arranged in three tiers, the top one being used for storing the pipes and rods, and the two lower ones for the other parts. The parts taken from each engine are by this means kept properly segregated and the workmen can easily and quickly get any particular portion of an engine at any time.

Another item is the use of a number of small compressed air supply tanks, which are scattered throughout the yard, and which are considered to be more convenient and efficient than a single large one.

There are eleven of these tanks located at various points, and they serve to supply air, to the various air driven tools, and for testing purposes. As already stated this arrangement provides a much better supply of air than would be the case if only one large tank were to be used. The accompanying illustration shows eight of these air tanks located just outside the power plant. The main air lines through the yard leading from them are 4 in. in diameter.

There is also an outdoor air pump testing department which is equipped with an air hoist having a radius of action of about twenty feet, which is used for handling



Out-Door Air Pump Testing Department at Southern Pacific Company's Bay Shore Shops

the pumps to and from the test racks. Facilities are such that three air pumps can be attached to the testing rack at one time.

A special air tank is provided which supplies the proper air pressure for testing the air brake apparatus such as feed valves, brake valves, triple valves and distributing valves.

The California climate is so mild that the testing can be carried out in the open all the year. A special steam line leading to this testing plant supplies the steam for operating the air pumps while the tests are being carried out.

Inspector of Locomotives

An examination for inspector of locomotives will be held throughout the country on November 5 and 6. It is to fill vacancies in the Interstate Commerce Commission at an entrance salary of $3,600 a year. Appointees will be allowed necessary expenses when absent from headquarters in the discharge of their official duties.

The duties of this position are personally to inspect locomotives and to see that carriers make inspections in accordance with the locomotive inspection law and the rules and regulations established thereunder, and that carriers repair any defects which such inspections may disclose before the locomotives or appurtenances thereof are again put in service; to investigate and report upon accidents caused by failure of any part or appurtenances of the locomotive or tender resulting in damage, injury, or death; and to perform other work as assigned.

Competitors will be rated on spelling; artithmetic; practical questions relating to the construction, testing, inspection, repair, and operation of locomotive boilers and their appurtenances; practical questions relating to the construction, testing, inspection, repair, and operation of locomotives, their tenders, and their appurtenances; report writing; training and experience in railroad work, and general fitness.

Full information and application blanks may be obtained from the United States Civil Service Commission, Washington, D. C., or the secretary of the board of U. S. civil-service examiners at the post office or customhouse in any city.

Annual Convention of the Traveling Engineers' Association

The thirty-second annual convention of the Traveling Engineers' Association was held at the Sherman Hotel, Chicago, Ill., September 16, 17, 18, 19, 1924.

The convention was called to order by its president, Mr. T. F. Howley, presiding, and following a most interesting and valuable address by Mr. R. S. Parsons, vice-president of the Erie Railroad, an address of welcome by Mr. Crowe, states attorney for Cook County, representing Mayor Dever, and the address of President Howley. The convention at once got down to business and during the four days' sessions accomplished much in the way of constructive progress of value alike to the membership and their employing companies. There was a total registration of 1,379 attendants at the convention, of which 482 were members of the Traveling Engineers' Association, and 383 members of the Railway Equipment Manufacturers' Association.

In addition to the addresses of Vice-President Parsons of the Erie Railroad and President Howley at the opening session, Mr. A. G. Pack delivered a most interesting and valuable address at the afternoon session, Wednesday, 17th, which will be found elsewhere in this issue.

Exhibits

There were about 108 exhibits at the Convention all in so close proximity to the Convention room that the members had an excellent opportunity to see the latest devices used on locomotives without detracting from their duties at the various sessions.

These exhibits were not only splendid in character, but were conveniently arranged with competent and obliging men in charge and suitable literature. So that without loss of time one could acquaint himself with latest development of the art, thus adding to the value of discussions in the sessions.

Papers and Discussions

The advance copy of committee reports of subjects for discussion at this convention covered 98 pages subdivided as follows:

Work of the Traveling Engineers	3
Conservation of Fuel	44
Locomotive Lubrication	13
Mechanically Fired Locomotives	6
How to Improve Oil Burning Locomotives	8
Passenger and Freight Train Handling (Brakes)	3
Automatic Train Control and Devices	13
Locomotive Booster and Its Effect on Locomotive Design and Train Operation	8
Total	98

The foregoing papers were read and discussed at considerable length and the printed proceeding of this session will be among the most valuable of the entire 32 volumes comprising the annual proceedings of the association.

Paper on Fuel Conservation Including Feed Water Heater

The paper on Fuel Conservation Including the Feed Water was somewhat unique in that it not only comprised more than 44 per cent of all reports combined, including charts and tables, but treated the subject in a manner from most all angles, reducing the terms of money the savings, which have been and should be made in future. The sum total of savings in railway fuel yet within the range of possibilities being placed at about $72,919,200. It is also clearly pointed out in this paper that in striving for the above goal the efficiency of locomotives would be materially increased aside from the actual saving in fuel.

By a unanimous rising vote the Convention extended its thanks to the committee for this paper and designated it as the most valuable one contributed during the association's existence.

Abstracts from Mr. Pack's address and of the reports to the Convention are published in the following pages.

Locomotive Maintenance

By A. G. Pack, Chief, Bureau of Locomotive Inspection, Interstate Commerce Commission

One of the first questions to be considered is whether you, as traveling engineers are permitted by those in authority over you, to always do the things that you know ought to be done at the proper time and place.

The locomotive inspection law has placed upon every common carrier by railroad the duty to so construct, equip, and maintain their locomotives that they may be operated without unnecessary peril to life or limb; and has placed upon you, as employees of such carrier, the same duty and has given you an authority which cannot be properly evaded, and one which if taken advantage of will help you in having the things done that your training and experience has taught you should be done.

Locomotives have grown in size and complexity, within the memory of man, as the mushrooms grow. Many of you remember when the 18 in. x 24 in. cylinder engine was considered enormous in size and believed to have reached the limit, but, it is not uncommon at this time to find cylinders ranging on simple engines as high as 30 by 32 inches with boilers carrying 240 to 250 pounds steam pressure, while only a few years ago 150 to 160 pounds was considered excessive.

During the past twenty years the number of locomotives have increased from 46,743 to 65,008 on Class I railroads; while the tractive effort has increased from 1,065,874,292 pounds to 2,576,433,377 pounds, an increase in the number of locomotives of 39 per cent with an increase in tractive effort of about 141 per cent, about three and one-half to one.

The many complex appliances that have been added to the locomotive in recent years, have increased the burden of maintenance; but, if this maintenance is neglected, the result may be engine failures, break-downs and delays. Every engine failure carries with it the potentiality of a serious or even fatal accident.

Engine failures cause confusion in operation and may be the consequence of a failure to make repairs of the most trivial nature. Men on the railroads in their effort to avoid train delay are induced to take chances. The "chance-taker" sooner or later comes to grief and too often pays the penalty with his life or the loss of his position. Desperate "chance-takers" have no place in connection with our modern methods of transportation—it doesn't pay.

It has been charged that the defects to which federal inspectors take exceptions are of a trivial nature and that the repairs to such defects are trivial, with which I agree; but, when the failure of parts and appliances of the locomotive and tender cause injury and death and the serious loss of property, of which we have many records, it cannot be considered as a trivial matter. The proper time and place to make repairs is at the terminal and before locomotives are offered for service. It is better, viewed from any angle, to have trains delayed at the terminal than it is to have engine failures, break-downs, and serious accidents on the line of road.

It used to be the practice to assign regular crews to regular locomotives, when the crew rested the locomotive rested. Under such conditions there naturally developed a keen interest on the part of the engineer and fireman in maintaining their locomotive. Personal effort on their part was most frequently exercised and close supervision of repairs was given. Then came the practice of double crewing. Today we find the almost universal practice of pooling or chain-ganging locomotives. When locomotives are pooled the result is a vastly increased burden upon those whose duty it is to see that they are properly maintained. It cannot be expected that an engine crew will develop that same spirit of pride in a locomotive which they only occasionally run, as where they are regularly assigned and where they feel a personal pride in the performance of.

In considering locomotive maintenance, the subject naturally divides itself into two parts—"classified repairs" and "roundhouse repairs." The backshop is the place where the heavier repairs should be made and should be equipped for that purpose. The roundhouse is the place where the lighter or current running repairs should be made and should accordingly be equipped. When classified repairs are made in roundhouses or when running repairs are made in back-shops, the logical order of things is violated, consequently, unsatisfactory and inefficient results obtain. It is not uncommon to find a large portion of roundhouses blocked with locomotives undergoing classified repairs which could be more promptly and economically made in the back-shops, while locomotives which should receive terminal attention in the roundhouse are being repaired on the outside without facilities and where men are compelled to work under the most adverse conditions and exposed to the elements. It goes without saying that such methods tend toward improper repairs and higher cost of maintenance with extremely unsatisfactory results.

The attention given to providing repair facilities for shop and engine house, has produced many examples of high efficiency, and those carriers who have not kept pace with the changed operating conditions should realize that inadequate shop facilities and poor oragnization means failure to make the best use of our resources and means a higher labor cost with the added cost which results from holding locomotives out of revenue service and the necessity for a greater number of locomotives to handle a given business. It is of vital importance to successful operation that careful inspection be made of every locomotive after each trip or day's work and to have the defects disclosed reported to the proper representative of the company, because if the existing defects are not known it is not likely that repairs will be made. Further, if repairs are not currently and properly made, the little things accumulate and the result is engine failures with attending delay to traffic and decreased efficiency. It seems hardly necessary to urge the importance of making proper inspections and proper repairs currently, because the results of failure to do this are too well known and because it is to the interest of everyone connected with the operation of railroads to have these things done.

Notwithstanding, during the past 13 years federal inspectors have been compelled to order withheld from service 48,836 locomotives because of defects which unnecessarily increased the peril of operation and decreased the efficiency of the locomotive. Practically all of this number had been pronounced ready for service or were actually in service with defects constituting violation of the statute and of economic law.

Comparing engine failures, one road with another, is of little value because no standard has been fixed; but, there is no better index as to the condition of locomotives than an accurate comparison of engine failures on a given road. As engine failures increase, the standard of maintenance is decreased, and is reflected by the increased number of accidents and casualties. As I have said before, engine failures are potential sources of serious accidents, with the resultant loss of life and limb as well as property damage.

This was very forcibly brought to my attention about one year ago on one particular line where we were encountering considerable difficulty in having the requirements of the law complied with. A vice-president went so far as to request that the federal inspector in that district be removed to some other district because of alleged prejudice. This vice-president requested a conference with me at which the superintendent of motive power was present, when the conditions to which exceptions had been taken were discussed in their various details. The conclusion was reached by this same vice-president, "that he wanted the inspector about whom complaint had been made to stay on his line and wished that he had more inspectors on his line because they were developing and putting before the management the conditions that cause engine failures, train delays, accidents and injuries." What has been the result? During one year there were about 400 engine failures per month with an average of 3,545 miles per failure. A year later the number of engine failures per month had been reduced to about 90 and the miles per engine failure had been increased to about 15,000. This is a vivid contrast between proper and improper inspection and repair.

After current repairs have been properly made, natural wear brings the locomotive to a condition where repairs of a heavier nature are required, heavier than can be properly and efficiently made in the roundhouses. The locomotive should then be taken to the back-shop and so repaired and restored that it will safely and efficiently perform a proper term of service with a minimum of so called "running repairs." In doing this, the different parts should be restored to standard dimensions as fixed by standard drawings and standard practices, established and adopted by every well-managed organization. Good shop practice calls for care and diligence in every detail from the time the locomotive is stripped to the time it reaches the testing track, and there made ready for service. Good tools maintained in proper condition should be provided. Sledge hammers and chisel bars send more material in the scrap-heap than do years of service.

The subject of locomotive maintenance may be properly considered in two parts—maintenance of boilers and appurtenances; next, maintenance of machinery and tender, and appurtenances. No locomotive is better than its boiler. A boiler which is poorly designed and poorly constructed is difficult of maintenance. Marked advances have been made in the design and construction of locomotive boilers, while the original principal is still retained, tending toward better circulation of water and better distribution of expansion strains. No matter how well constructed a boiler may be, it cannot be safely or efficiently operated without current inspections, tests, and repairs. No one disputes this but it is surprising to learn the large number of locomotives upon which defects have been reported trip after trip and day after day and still continued in service without regard to the peril created or the monetary loss indirectly incurred.

One of the first considerations in maintaining boilers is that of water supply. Those of you who are connected with the operation of locomotives in bad water districts know of the problems arising from this source, both from the maintenance view-point, and of getting over the road with a train. Modern locomotives are bringing with them better combustion and higher temperatures. Light foamy water or water that leaves incrustation, cause overheating and sheets to crack. Too much cannot be said for the necessity of removing all washout plugs and thoroughly washing all parts of the boiler as often as water conditions require. It is too often true that boiler washing is neglected which is always reflected by increased trouble and cost of maintenance. When sheets are coated with scale, thus insulating them from the water, the water cannot absorb the heat readily and the result is increased temperature and strain with a corresponding increase in trouble and decrease in evaporation. Some of the best authorities have said that 1/16 of an inch of hard scale on the water side of heating surfaces consumes approximately 15 per cent more fuel than when kept clean. Marked improvements in water supply have been made in many places by the installation of treating plants and in others by changing the source of supply. Conditions have been vastly improved, in many instances, by installing modern washout systems. These improvements cost money and it is possible to spend without getting an adequate return which should be guarded against; but, when one considers the reliability and efficiency of service that is to-day required of locomotives, it becomse apparent that any reasonable expenditure in providing better water and proper washing facilities is ultimately a paying proposition. There is a close and inseparable relation between locomotive maintenance and fuel economy. The increased cost of fuel has made it a matter of prime importance and is attracting the widest attention among the railroad managements at this time.

Efficiency and economy of operation have influenced the application of brick arches, superheaters, combustion chambers, feed water heaters, and many other appliances, which must be properly maintained if the desired results are to be accomplished. Since steam is the propelling power the problem to generate it freely and to use it economically is an all important question. To this end locomotives should be so maintained that the distribution of the steam to the cylinders be most effective, and that the machinery is in condition to utilize the energy created to the highest possible degree. Rod bearings which are loose and in bad condition, boxes loose on journals, shoes and wedges out of adjustment, loose and worn cylinder packings which blow, valves out of square and blowing, are poor mediums through which to transmit the energy and adversely affect the draw-bar pull and the earning power of the locomotive.

One of the unfortunate situations confronting the mechanical departments is the manner in which their appropriations are made. It is my thought that an annual, instead of a monthly, budget or allotment should be made. One of the most important considerations in the matter of locomotive maintenance is to have a corps of competent, steady, reliable, and contented employees. We must have contentment if the best results are to be obtained; discord and confusion among employees is not conducive of the best results. Discontentment and confusion are bound to ensue when employment is uncertain and irregular.

There is nothing which so adversely affects economy of locomotive maintenance as to tear the mechanical organization to pieces each month or at frequent intervals in order to keep within the appropriation or to fluctuate the personnel with every temporary traffic change. I appreciate that revenues can not be disregarded when making expenditures, but, with proper consideration, forethought and foresight, expenditures can be anticipated with sufficient accuracy and the mechanical forces so regulated as to provide steady employment. Steady employment at remunerative wages brings about a satisfaction among employees that is hard to disrupt; while on the other hand, when men are treated as machines and laid aside without regard to consequences, and without a good sound reason, it breeds anarchism, bolshevism, unrest and disloyalty, and brings hardships, not only upon the men thrown out of employment, but upon everyone connected with the organization.

Again, locomotives cannot be properly and economically maintained if repairs are neglected until the rush period is on. It is then that the locomotives should be in revenue service and not in the shop; it is then that the transportation department is pressing for motive power. Therefore, in keeping with sound management the locomotives should be repaired in dull periods and be available in a high state of repair when the rush comes, if traffic is to be most efficiently and economically handled.

The last time I was before you I discussed in some detail the circulation of water in the boiler and its effect upon the water indicating appliances. A description was given of numerous tests and invetigations made which clearly established that gauge cocks, when screwed directly into the boiler, do not correctly indicate the general water level over the crownsheet under the varying conditions of service, and I recommended that a suitable water column to which should be attached three gauge cocks and one water glass be applied with an additional water glass on the left side or backhead of the boiler. Since that time I have had no occasion to change my mind or alter the recommendation. It is essential, to safe and economic operation of locomotives, to have water glasses and gauge cocks so applied that they will under all circumstances register correctly. Water glasses and gauge cocks should be so located, constructed, and maintained, as to be easily visible from the widest possible range in the cab and be conveniently located Practically all new locomotives constructed since that time have been so equipped, and a large number of the locomotives previously in service have been changed in accordance with my recommendation.

Election of Officers

At the closing session the officers elected for the ensuing year were as follows: President, W. J. Fee, Canadian National; first vice-president, J. N. Clark, Southern Pacific; second vice-president, J. H. Hurley, Wabash; third vice-president, J. D. Heyburn, St. Louis, San Francisco; fourth vice-president, James Fahey, Nickle Plate; fifth vice-president, Ralph Hammond, New York, New Haven & Hartford; David Meadows, Michigan Central, was re-lected treasurer, and the following were elected new members of the executive committee: A. N. Boyd, Canadian National; G. C. Jone, Atlantic Coast Line; H. B. Kelley, Pittsburgh & Lake Erie; Robert Collett, St. Louis, San Francisco; H. H. Wilson, Baltimore & Ohio, and C. J. Evans, Missouri, Kansas-Texas.

Locomotive Boosters and Their Effect on Locomotive Design and Train Operation

The demand for efficiency and economy in locomotive design and service is increasing every day. Every new idea that can be worked out successfully along those lines is speedily accepted by railroad managements. Consequently when the booster idea was conceived and grew into a working model and a very successful one, it has met with most gratifying success in a short time, being used first on the New York Central in 1919.

The modern locomotive with its large boiler and fire-box and its powerful reciprocating engines is an answer to the continuous demand for more power, bigger locomotives to haul more tonnage and still larger locomotives to haul the tonnage faster. To provide these engines with steam requirements, large heavy boilers were necessary. This in turn called for larger fire-boxes. To support and carry a portion of this increased weight, the trailer axle and truck were introduced. This applies to both passenger and freight locomotives.

The greatest difficulty in handling a maximum tonnage train is in getting it started as well as getting it over the grades. It is a well-known fact that the tractive effort necessary to start a train is far greater than the effort required to keep the same train in motion. It is also true that the horsepower the locomotive develops is greater while in motion than when starting from rest.

For many years engineers have worked on this principle without success, until in 1918 Mr. H. L. Ingersoll, Assistant to President of the New York Central Lines, developed the booster and brought it to its present high standard of efficiency. It is now considered a necessary appliance and has been placed on over 1,450 locomotives on forty-three different railroads in the United States and Canada, and application have been made on locomotives on several foreign roads.

The locomotive booster is a horizontal two-cylinder double-acting steam engine mounted on the trailer truck and connected directly to the trailer axle of the locomotive through suitable gearing by which it may be engaged or disengaged at will.

It is designed for applying power to the trailer wheel in the *forward motion only*. It cannot be operated when the engine is in back motion.

It is self-contained and has a flexible mounting in the form of a three-point suspension. Bearing on the trailer axle are two of the points, while the third is the spherical seat at the center of the rear cross member of the truck frame, which later allows free movement of the booster with the varying positions of the trailer axle.

The engine is a very simple type, consisting of two 10 x 12" cylinders with piston valves taking steam direct from the dome or from the steam chest. Steam is admitted to the cylinders three-quarters of its stroke and has no variations in cut-off.

Steam admission is controlled automatically at the will of the engineer. Exhaust steam passes through flexible connections from the booster engine to the atmosphere through the exhaust muzzle and stack.

The machinery of the booster consists of a crank-shaft driven by the booster engine which in turn drives the idler gear so placed as to mesh with another gear on the trailer axle, by means of the automatic air-operated clutch, driving the trailer axle, thereby making a temporary driving axle to assist the main driving axles in starting or exerting increased effort as needed.

When the train reaches a speed of about twelve miles per hour, the idler gear is automatically released by the reverse lever which is pulled back to reach a pre-determined point so it disengages the latch of the pilot valve, or the engineer can disengage it by knocking down the booster latch. The booster is then inoperative, in which condition it exerts no power, but is available when extra power is needed.

The purpose of the booster is to provide (1) additional starting effort; (2) increased power for acceleration; (3) additional tractive effort on grades.

It can be attached to the trailer truck of the locomotives and is a reserve power that can be quickly applied when needed and as quickly released when not needed.

It can be used in starting trains and until they reach a speed of twenty miles an hour when it should be disengaged.

The starting power of the locomotive is governed by the weight carried on the drivers. The trailer axle usually carries as much weight as one pair of driving wheels. Various ways have been devised to utilize this idle weight of the trailer wheel and axle and divert them into a driving wheel.

This is where Mr. Ingersoll's idea has been successfully developed. Being a practical railroad man, he realized that to apply his idea correctly certain limitations and functions must be considered, such as:

First—Minimum amount of changes on existing locomotives.

Second—No disturbance in the relation between the fire-box trailer axle and diameter of trailing wheel.

Third—Installation of the power units so that it would deliver the torque to the trailer axle without in any way affecting the action of the rear end of the locomotive.

Fourth—Additional power is desired only at starting and low speeds, when the boiler can supply more steam than the main engine can utilize; hence the power unit should normally be controlled by the engineer, but should be inoperative automatically after the locomotive has attained a pre-determined speed.

Fifth—No interference with the functioning of the locomotive at high speed.

What the booster is capable of doing in passenger and freight service:

First—It is an aid to smoother starting and quicker acceleration which results in greater comfort to passengers.

Second—It is an assistance of sufficient power to start trains under adverse circumstances and increased tonnage.

Third—It avoids taking slack in starting trains, resulting in reduced cost of equipment maintenance. Also in many cases the use of expensive helper service is elimianted.

Fourth—Increase the ton miles per hour per locomotive over a division.

It is of equal importance in hump and transfer service, as it assists in starting trains with less damage to equipment. Tests in yard service show there was an increase of about fifteen per cent more cars handled per engine than by the same class of engine without booster.

The engineer must provide proper lubrication for the booster engine by starting the lubricator far enough in advance so that lubricants will reach the cylinders before the booster is operated. He must also observe closely that no time intervenes between the meshing of the gears and the functioning of the controls. Should he notice a lapse of time a report should be made on arrival at the terminal.

In the ability to add increasing starting and accelerating power to existing locomotives lies the hope of lower transportation costs through more tonnage haul per unit.

In the locomotive booster lies the realization of this hope. Boosters now in service show an addition in starting power to the 2-10-2 type of 10 per cent, the Mikado type of 23 per cent, the Pacific type of 27 per cent, and the Atlantic type of 36 per cent.

The effect of the booster on the locomotive is merely an increase of 5 per cent in static stresses, well within the allowance in every-day specifications for bridges, buildings and other mechanical construction.

The increased power has decreased by almost half the time required to get trains to road speed.

By providing the extra power needed to give a smooth, steady start, booster locomotives avoid the necessity of taking slack, thus reducing draft gear maintenance, now one of the largest items of freight car repairs.

Where train loads have reached the utmost limit of a locomotive's capacity, very little power is left for acceleration. The application of the booster means a faster start, a quicker run through the yard, a more rapid acceleration to road speed, resulting in a material reduction in overtime and car rental payments.

At congested terminals, the time one train ties up the yard pulling out over a ladder track is reduced radically when the locomotives have boosters.

Operation with the booster is like having a "pusher" always ready. In fact, booster locomotives are fast eliminating the need of "pushers." In one case a booster by working only 23 minutes in 7½ miles eliminated 70 miles of pusher service per train and just that much interference to other trains.

By the application of boosters to light Atlantics sufficient starting power is added to permit them to handle heavy trains, thereby releasing the big locomotives for other heavy work.

At every needed point on the railroad and on any engine the booster speeds train operation.

These operating results are being secured by a booster equipped Mikado over the 100 per cent tonnage rating of twenty-three similar Mikados not booster equipped:

Increased tonange	392 tons
Ton miles per hour	392×100=39,200
Ton miles per 100 miles for 30 days	39,200×30=1,176,000
Additional earnings, \$.0007 per ton	1,176,000×\$.0007=\$8,232
Additional freight, one way only	\$8,232÷2=\$4,116.00
For one year (300 days in service)	\$4,116.00×10=\$41,160.00
Revenue tons compared with total tons	67%
Actual increased earnings	\$41,160.00×67%=\$27,577.20

The report was signed by W. H. Corbett, chairman; J. A. Talty, H. L. Symons, P. H. Ryan, F. W. Stoll and W. B. Smith.

What Effect Will the Mechanically Fired Locomotive Have on the Future Engineer?

We, your committee assigned to handle the above subject, believe that perhaps it might have been well to have added, "and how will this reflect on train operation?" because good train and engine operation depends practically on the enginemen, and, consequently, the subjects may be said to be interrelated.

Although the conductor and rear brakeman may not agree with this statement, yet it is our opinion that it requires more brains to run a locomotive as it should be run, than to run a train.

The modern locomotive and the present-day train cannot be handled successfully by skill and instinct only, but in addition to skill it requires rare judgment, thought and resourcefulness. This can only be obtained through the exercise of the mental faculties, and as the exercise of the mental faculty presupposes a mind or brain, we get right back to the first proposition, that it takes brains to run a locomotive. And thus we have as the first part of our problem the fact that the engineer, to be an engineer, must have a good active brain.

The next part of our problem is: Where will we get this man? In this connection, we think it well worth while to repeat the opening paragraphs in the very able paper presented before this association by Mr. J. B. Hurley in 1922, on the Employment and Education of Engineers and Firemen, viz.:

"In the past when locomotives were small and always easily handled in case of breakdowns and when the pooling of power had not become as universal as it is today, an entirely different method of employing, educating and examining enginemen naturally obtained than under present conditions.

"In the first place, railroading held out attractions greater than other lines of employment, as far as wages, physical labor, etc., were concerned. As a result there were usually more applicants than there were jobs, and consequently it was possible to pick from the applicants the men whom we thought best suited for the position. The position of locomotive engineer was worth working for and as the first step in this direction was a job as fireman, it followed that there were many applicants for this position. Foreign labor was not as plentiful as it is today, and consequently what are now termed laboring jobs, such as wiping, knocking fires, cleaning cinder pits, helping machinists and hostlers, and other jobs about roundhouses were filled by young Americans, and each of the above positions were considered as in line for a job of firing. Entering the roundhouse usually as a wiper, the young man graduated to a position of fire knocker, then to that of hostler helper, and then as fireman on a switch engine. The result was that during the time he knocked about the roundhouse in the above capacities he absorbed a lot of valuable information covering the construction, care and maintenance of a locomotive.

"When he finally became fireman on a regular engine, it was expected of him and the engineer to take care of it, and as the locomotives were small, it was seldom more than a two-man job in case of accident to disconnect any broken parts and load same up or to make such temporary repairs as would enable them to get the locomotive to the terminal. They became thoroughly familiar with this part of their work and, consequently, any instructions handed to them were along the above lines, and any examination given them necessarily embraced more what to do in case of accident, so as to enable them to bring the engine in, that the actual running of the locomotive or handling of the train, it being taken for granted that a man who was thoroughly familiar with the construction of the machine and had some experience as a fireman, would be equally as capable of successfully running the engine and handling the train.

"Since this time, however, things have changed—the old-time engine as well as the old-time engineer are largely a thing of the past. The engine crews no longer take care of the same breakdowns they used to handle with ease years ago; other conditions have changed likewise, that is, other fields of labor are proving more attractive from a financial point of view than locomotive running. Again, due to the fact that locomotives are increasing in size and capacity with the increase in business, it follows that the firing period to promotion is likewise extended, therefore we are finding it more difficult all the time to obtain satisfactory material from which to make our future engineers."

In the above quotation your committee stated it was becoming more and more difficult to obtain the right kind of men from whom we must draw to get the future engineer. Why? Looking for the answer brings us back to the original proposition, viz., that it takes brains to run a locomotive, and as our only source of supply is from the left side of the engine, it follows that the fireman must have brains or he cannot become an engineer.

The above being granted, it is evident that the man we must hire to fill the fireman's job must be equipped with the necessary thinking faculties.

Granted, then, that we set out to employ a man who can think. We place him on a large hand-fired engine to learn the art of firing. When he looks back he sees from sixteen to twenty tons of coal staring him in the face. On the deck he sees a large scoop, a coal pick and a clinker hook. He turns around and sees a fire-door which, when opened, pours out a stream of heat that will burn the overalls off him if he gets too close, and near the door a shaker bar and a bunch of shaker levers. He is told that all he has to do is to crack the coal, throw it into the fire-box, and then shake down the ashes.

When he sees the regular fireman throwing in coal "to beat the band," he begins to wonder if they will have enough to take them to the next terminal, which he has been informed is a hundred or more miles away; but he is immediately cheered by being informed that there are more coal chutes along the line, and when what they have on the tank is used up they will stop and get some more.

Understand, this man is out on his first student trip, and the regular man is doing most of the firing; therefore, after he has filled the torch and the hand oilers, swept the deck, wiped a little dust off the boilerhead here and there, and finished the other little chores that the fireman is supposed to do while he is resting, he has a little time to stand in the gangway and view the scenery while Mr. Regular Fireman is breaking his back heaving coal. (The regular fireman has no time to "rubber," take it from us; we know.) So while they are ambling along, he sees some men building a house. He had just been reading in the morning paper before he went out, that the wages of bricklayers had been raised to $2 an hour; that carpenters were getting from $1.25 to $1.75 an hour, and that latherers and plasterers got $25 a day. (These are Chicago prices.) He sees a man repairing an automobile; he knows what they get, because his dad owns a car.

He looks all around and sees men employed in gainful occupations, and has a fairly accurate idea of what their wages are. Finally he looks over at the brakeman comfortably perched on his seat ahead of the fireman's seat-box (where he is always in the way) and timidly asks him, what he is supposed to do, and is gruffly informed that he has to "work, throw switches, flag, pick up and set out cars, etc.," but as they are now more than half way over the road and have not picked up or set out a car or thrown a single switch, he wonders if the brakeman is taking advantage of his ignorance and is joshing him. So he asks the fireman what the brakeman is for, and is informed, "as an ornament, and he gets more for riding than I do for working."

Remember, this fireman that we are trying to break in is the man with brains, and as he goes along his "think tank" begins to work; finally when they get in and are humped up over the lunch counter filling up on coffee and "sinkers," he asks the regular fireman why he went firing, and gets as a reply, "because I was a damn fool, I guess. I thought I would only have to fire three or four years, when I would be promoted; but every time I get close to the top of the list the company buys two big engines that take the place of three little ones, and there I am, at the end of ten years, nearly as far from promotion as I was when I started." Our thinking friend turns in; not much time to take a bath or clean up right, as they are told they would get out on their rest; but regardless of the fact that he did not work very much, he is rather tired nevertheless, and he realizes that he was mistaken when he thought the engineer had a snap because he seldom got off the seat box, for he now sees that even that must be work, for he himself who did not do any more actual labor than the engineer is mighty tired just the same.

However, even though he is physically tired, he cannot go to sleep. He keeps thinking, thinking, and when the caller calls him for the return trip, he is still thinking.

He is allowed to do a little more firing going back. They also let him take water, and he wonders how it feels to get from in front of the fire-door, scramble up on the tank and hold the spout down for three or four minutes with the thermometer registering around zero and the wind blowing a gale.

All the way he keeps thinking. He again passes the garage, sees the man tinkering on a car, and visions the day when that man will have a garage of his own.

He sees the men building the house, and visions the time when each of these, the carpenter, the bricklayer, etc., can by proper application become contractors; in fact, every place he looks he sees possibilities of promotion, until he looks at the fireman, and then he begins to figure: "Let me see—I am twenty-one now; if promotion continues as slow as at present I will be nearly forty before I am promoted. I wonder if the romance of the calling won't be somewhat worn off by that time—I wonder."

When they get back to the home terminal, he has worked out the problem to his own satisfaction. He gathers up his few belongings, thanks the engineer and fireman for their help and courtesies, and "beats it." Does he ever come back? Well, hardly ever, and so the Traveling Engineer who employed him feeling that he caught a prize, has another bright dream shattered, and looks around for another man who don't think so much.

Going back to Mr. Hurley's paper we quote: "Every day in every way it is getting harder and harder to get the right kind of men for the hand-fired engines." What is the answer?

Try to get back to the old system as near as possible. True, we cannot hurry promotion; neither can we go back to the small engines, nor can we (even if we so desired) stop the march of industrial progress in those other directions that hold out possibilities to the young American—but we can make the fireman's work more attractive by making it easier. We can fire locomotives mechanically and thus relieve him of the hard manual labor and give him time to think and study to fit himself for the position he aspires to.

Do you think if our student fireman who had decided to take up railroading as a lifework, had got on a stoker-fired engine, he would have quit the job after one round trip? If you do, you are not familiar with human nature. On the contrary, he would have become so interested that he would not have been satisfied until he mastered the machine, and by that time he would have seen that there were other possibilities ahead of him in railroading beside running an engine, if he only applied himself: but when a man is worn out physically you can't expect much from him mentally, and the thinking man realized this and got off.

Going back to the beginning—if we want to maintain the high standard of enginemen that we have at present and that the service demands, we must begin with the fireman. Of course, we appreciate the fact that on all railroads there will always be hand-fired engines. The thinking man will realize this also, and so long as these engines are within the capacity of the fireman he will not let that stand in the way of his accepting service, as he can see that after his term on the hand-fired engine has been served he will get a stoker-fired engine, a job that aside from the pay is nearly as good as one on the right side. And the ultimate effect will be that the present high standard of enginemen, of which we are all justly proud, can and will be maintained, and the railroads will derive benefits through better train and engine handling far in excess of the financial outlay.

Your Committee for a number of years has watched the evolution of the mechanical stoker and its increased efficient operation by the fireman. We also have noticed the increased knowledge pertaining to locomotive operation that the regular assigned stoker fireman has absorbed. In the past when we had all hand-fired engines if you asked a fireman how much coal he used on the trip, he would usually answer: "Oh, I don't know—about two tanks full." Nowadays it is different. On the road with which your Chairman has had the good fortune to be connected it is not unusual to get up on our stoker engines and ask the fireman: "How is the fuel consumption showing up on this engine?" He will answer right off: "Oh, about so many pounds per 1,000 gross ton miles or per passenger car mile." And that is not all. He will tell you whether or not the evaporation of water per pound of coal is what it should be and a good many other things that he did not know while on the hand-fired engine. He will talk to you about the air openings in the ash-pan, and why he has to carry a lighter fire on one engine and a shade heavier on another.

Now why can this fireman talk so intelligently about locomotive operation? Because with the stoker-equipped engine he has time to think and study. Let me give you one example of a fireman who had learned to think. Your Chairman was operating a locomotive with 100 tons over the rated tonnage of the locomotive. In order to make a meeting point for four passenger trains, he said to the fireman: "We will run this next water station and go to K. for water." He said: "That's good, and we will have about ten inches of water in the tank when we get there." As this fireman had not looked into the tank since last taking water, I wondered how he knew just how much water would be in the tank on arrival at K. (this being an unusual run he had never before made with such a heavy train). In conversation with him he explained why he could tell without looking into the tank. He stated that he knew from the uniform maximum steam pressure, the very light fuel consumption and the quarter turn of the water valve to injector that the engine was not using much water.

The mechanically fired locomotive is quite a factor in educating the fireman not only in the economical firing of the engine, but also enables him to better observe the manner in which the engineer handles the engine. Another fact is that the stoker has a tendency to make the fireman more mechanical. He feels there is a certain amount of responsibility attached to the operation of the stoker. Therefore he gives more attention and thought to the locomotive as a whole than when on the hand-fired engine.

From a safety standpoint the mechanically fired locomotive has the advantage of two men being constantly on the lookout. Inquiry of one railroad brought out the fact that there was no record of any mechanically fired locomotive running by a block or red board. This in itself is of more value than appears on the face. One bad rear end collision will pay for any number of stokers.

We, the Committee, beg to report that the mechanically fired locomotive will in our opinion enable railroads to employ high-class young men for the position of fireman, who in time will become high-class engineers, and in the end the railroads will profit by it with increased tonnage, reduction of number of hours on the line, reduced fuel consumption and less fire-box and boiler maintenance expense.

The report was signed by James Fahey, Nashville, Chattanooga & St. Louis, chairman; F. P. Roesch, Standard Stoker Company; A. N. Wilsie, Locomotive Stoker Company; H. Von Erickson, Great Northern; W. T. Hanna; N. Shurie and R. Hammond, New York, New Haven & Hartford.

How to Improve Oil Burning on Locomotives

Thirty years ago the first successful attempt was made to burn oil in the fire-box of a locomotive. These tests were conducted in Southern California where oil had been found close at hand, but where coal was very expensive and had to be shipped from considerable distances, some of it by boat from Australia. At the present time there is no coal mined within eight hundred miles of the terminal where oil was first tried out as a locomotive fuel.

Ten years after the first tests were made, Mr. Howard Stillman, Engineer of Tests of the Southern Pacific Co. made this statement: "Unfortunately for the evolution of exact principles in burning oil in locomotives, the matter has been one largely of expedient. Locomotive boilers are designed for coal fuel and the matter of application for oil fuel at the start was experimental. Whether oil fuel would be permanent or not, was not established, and it is in many localities today an uncertain factor as to how long it may be before solid fuel will again be required. In the application of oil-burning appliances to locomotives, this has generally to be considered. It was formerly our boast that in emergency an engine could be converted over night in the roundhouse to oil burning or back again to coal, hence simplicity has been an important function."

During the past few years the use of oil as a locomotive fuel has been extended very rapidly and there are now forty-five railroads in the United States making use of oil fuel in locomotives to a greater or less extent. Last year these railroads used 57,600,000 barrels of oil valued at approximately $7,800,000.

With this widespread use of oil as fuel on our railroads, not only the most capable officers and employes of the railroads themselves, but the best combustion and designing engineers in the world have devoted their best efforts in producing the modern oil-burning locomotive. To say that it is not highly efficient would be to ignore the results of thousands of tests which plainly show that it compares very favorably with the most modern central stations and that it does so under serious handicaps.

It can scarcely be expected that a second Columbus will appear on the scene to show us new worlds to conquer, but none of us will care to admit that no improvement is possible in the burning of oil in locomotives. None of us are satisfied, nor do we think perfection has been reached.

How to improve the burning of oil in locomotives brings us face to face with the problem of securing complete combustion of a large amount of oil in a small space and during a very limited time. From the time a drop of oil leaves the burner tip until it is completely atomized, consumed and has reached the flue-sheet less than one second has elapsed.

There are four conditions ever present that must be met before complete combustion of oil can take place; first, the oil must be properly atomized; second, we must have the proper amount of air; third, we must have the proper temperature in the firebox; fourth, we must have a sufficient length of time for the thorough mixing of oxygen and gases and to complete combustion before they reach the flue-sheet.

Burner

That much thought has been given to the construction and design of oil burners is shown by the fact that more than 3,000 burners have been covered by patents in some form or other; yet the few steam atomizing burners in most general use on the largest oil-burning railroads are of simple construction, have stood the test under keen competition, and some of them are now unprotected, as the original patents have long since expired.

Many attempts have been made to introduce mechanical atomizing burners on locomotives, and no one doubts but what a more complete and thoroughly atomized oil spray may be obtained through such a burner, but the chief difficulty encountered is in the range required. A 2-10-2 type locomotive under maximum working conditions consumes 550 gallons or 4,400 pounds of oil per hour. The ordinary mechanical atomizing burner will deliver 300 gallons or 2,400 pounds of oil per hour, which would mean two such burners. The problem therefore appears to be one of increasing the capacity of the mechanical atomizing burner rather than installing more than one burner.

This subject is now receiving careful study at home through a trial installation of a mechanical atomizing burner on a switching locomotive of an eastern railroad. The burner being tested is the wide-range mechanical atomizing type of the Peabody Engineering Corporation. This burner was installed October, 1923, and no difficulties have so far been encountered in maintaining maximum steam pressure; neither is it necessary to clean soot from flues, as the oil is so completely consumed that no soot is deposited.

A very interesting experiment with mechanical atomizing burners on locomotives was conducted recently on one of the large French railroads. These tests were highly satisfactory and they now have thirty-seven locomotives so equipped. One burner is capable of taking care of a French locomotive, but their power is somewhat smaller than ours. This burner is the Whitehead Ray Rotary type, an American product. A dependable supply of oil for locomotive use is at present an unsolved problem with the French railroads.

That possibilities exist through application of mechanical atomizing burners for economy in the amount of steam used for atomization (the ordinary steam atomizer burner uses from 2% to 4% of the total output of steam) and for reducing the amount of fuel that is required by improving combustion, no one doubts, but there are some difficulties yet to be surmounted.

Steam is the spraying agent now in use to atomize oil, although certain people recommend the use of air. If you should experiment with air for atomizing, don't rob the compressor, for 100-car trains are the prevailing style and they keep the air pump fairly busy. From a mechanical point of view a cubic foot of compressed air would break up as much oil as a cubic foot of steam if both were at the same pressure. But taking the mechanical efficiency of the air compressor into account, a cubic foot of compressed air costs nearly twice as much as a cubic foot of steam at the same pressure. What is desired is that oil should be at the highest practicable temperature as close as possible to the burner tip. When air is suddenly expanded it absorbs heat. When heat is suddenly expanded it gives off heat. Therefore the use of compressed air as an atomizing agent tends to lower the temperature at the burner tip, while the use of steam as an atomizing agent tends to raise the temperature at the burner tip. It should be noted that this increased temperature is accomplished in two ways: first, by heat transfer due to coming in contact with steam, and, second, by absorbing heat given off by steam during sudden expansion.

The dryer the steam is used for atomizing the oil the better the result. Superheated steam therefore has the preference.

The burner offers a fertile field for embryo Edisons, and any Traveling Engineer from an oil-burning road will furnish specifications.

Burner Location

The standard location of the burner is in the front of the fire-box below the flue-sheet, the oil being sprayed toward the back end of the fire-box, where the flash-wall is located to deflect the flame, which then turns and travels again about the full length of the fire-box to the flue-sheet. This location was adopted after numerous tests with the burner in the back end of the fire-box, also with two burners, one in the front end and one in the back end of the fire-box. Of the mechanical burners mentioned above the one being tested on a switch engine is in the back end of the fire-box, while those on French locomotives are in the front end in the same location as our burners.

If it were possible to reduce the distance between the burner tip and the point of ignition, a much longer time would be allowed to complete combustion, the gases would have more time to give off their heat and the advantage of longer flame travel would be obtained.

Pyrometer tests show that the temperature of hot gases entering the tubes drops to about 1,300 or 1,400 degrees Fah. within eighteen inches after coming in contact with evaporating surfaces, which is about the lowest temperature at which complete combustion takes place. Where combustion is not completed by the time the burning gases enter the tubes it is a known fact that they are chilled below the igniting point and deposit carbon on the tubes in the form of soot.

A series of tests were made in the fall of 1919 and the present standard of front end burner without an arch or arch tubes was found to be the best arrangement and produced the highest efficiency.

During the past few months a test has been in progress with thermic syphons on 2-10-2 type locomotives with front end burners to determine if any economies are possible from the use of same, and since these syphons are in the same relative position as arches or arch tubes it revives interest in the subject and make one wonder if there would not be a possible field for some economy from further tests with arches in view of the fact they are part of the standard equipment on coal-burning locomotives. Three factors were against the use of arches in the tests previously conducted, namely, difficulty in connection with maintenance of arch and arch tubes and the expense and trouble caused by pieces of broken brick falling down in the path of the flame, sometimes causing engine failures, difficulty in sanding flues, especially the lower ones which were behind the arch, and the impingement of flame against the crown-sheet where the arch ended. With the advent of larger power and combustion chambers in fire-boxes we are confronted with somewhat different conditions. Have not the arches been improved through stronger construction and the use of better brick and other material? Will not the mechanical steam soot blower enable us to reach all the flues? The third feature of impingement is not so easy to overcome and may prove the stumbling block, although improvements in combustion through the mechanical burner may help out in some measure.

Air Openings

The proper location and the correct size of air openings in the fire-pan are of utmost importance. A safe rule is for air openings to be seven times the diameter of the cylinder. Sufficient air should be admitted around the burner to prevent it from becoming overheated. Too much air admitted around or under the burner unless proper damper control is provided may result in chilling the lower flues, as the air takes the line of least resistance and goes up the front brick wall and into these flues on its way to the stack. Leaky flues are often the result.

Admitting the major portion of air to the fire-box through a flash-hole varying in size from 8"x10" to 13"x20" and located from 9" to 18" in front of the flash-wall and a 2"x35" opening in the hooded fire-door is one practice on Southern Pacific Lines. The air openings are approximately as follows: flash-hole 25%, burner openings 5%, door damper 5% of the minimum area of tubes allowing for units. This is what is known as the vertical draft having the hooded door as against a solid door with a 5" circular opening used in sanding flues.

The horizontal draft differs slightly in that it admits the air through small openings in the front of fire-pan around the burner and through the hooded door. Each of these methods are in general use on the Southern Pacific Lines.

The draft-pan opening or flash-hole is also used by other oil-burning roads, but they also have a number of round openings along the side of the fire-pan over which an adjustable slide may be drawn by lever control from the cab to regulate the amount of air.

It is well known that an appreciable amount of heat is lost through radiation from the outside of the boiler, losses being greatest from the outside side-sheets of the fire-box. Engineers today are recognizing the fact that pre-heating the air means fuel economy. It may be possible to use at least part of the heat now lost through radiation for preheating air to the fire-box. As to how this can be done is a matter for development, possibly through the use of easily removable ventilating air ducts attached to the outside of the boiler, conveying the heated air to the present air intakes to the fire-box.

We all know that any air entering the fire-box must be heated for atmospheric temperature to the fire-box temperature. In order to consume 550 gallons of oil per hour in a 2-10-2 type locomotive fire-box, and obtain complete combustion without any excess air, 51,000 pounds of air are required, making the total weight of air and gases that must be passed out through the stack equal to 55,000 pounds per hour. Under normal operating conditions where as much as 25% excess air is encountered (and this amount is considered good practice), 63,000 pounds of air would be required or a total weight of flue gases equal to 68,000 pounds per hour. This requires approximately 750,000 cubic feet of free air taken in at atmospheric temperature, which must be raised to fire-box temperature and then exhausted through the stack at smoke-box temperature. Each 10% excess air passing through the fire-box increases the fuel bill approximately 1%, clearly demonstrating the fuel cost of improper drafting or careless operation of dampers.

Valves out of square do their own broadcasting, cylinder and valve stem packing blowing can be seen as far as the locomotive is in sight. Black smoke at the stack is also incriminating evidence, but excessive air resulting in a clear stack passes at times unnoticed and at the very moment may be wasting around 20% of the fuel.

Excess air will bear careful study for the following reasons: It reduces fire-box temperatures, increases gas velocity, reduces time for gases to give up heat which materially reduces efficiency of the boiler.

Dampers

The device which regulates the amount of air entering the fire-box plays no small part in maintenance cost and fuel economy. The usual damper control is by rod or chain connection from the cab. On the French locomotives mentioned above a worm gear control on the rod connection from the cab is now in use and gives very accurate adjustment of the damper.

At the present time there are two styles of balanced dampers being tested on Southern Pacific Lines, one is a butterfly damper enclosed in an air chute at the front end of the fire-pan and the other is a flapper damper which hangs in closed position over the front end of the fire-pan and is opened by draft when the engine is exhausting. Both are meeting with success, but neither has been in use long enough to pass judgment as to which is better.

The dampers on oil-burning locomotives are in a location where inspection and maintenance are difficult, which should lead us to perfect a damper which will require the minimum of attention and yet be always serviceable.

Furnace Design

Heating surface of the fire-box is worth five times as much per square foot for evaporative purposes as that of the tubes.

Anthracite coal is burned on the grate. As air is passed through the bed of coal the oxygen and carbon unite, mechanically forming complete combustion within the bed of coals. With bituminous coal the oxygen unites with the fixed carbon as with anthracite coal, forming complete combustion within the bed of coals, but the volatile part of the coal is driven off and must find its oxygen and sufficient temperature to complete combustion in the furnace space above the bed of coals. For practical purposes fuel oil is a 100% volatile coal, because the entire body of oil is sprayed and burned in the furnace space. From the above it is apparent that the greater the percentage of volatile matter the greater the furnace volume required. Therefore fuel oil or gas requires greater furnace volume than any other kind of fuel. When coal is burned the radiant heat from the bed of coals ignites the gases over the bed of coals. With fuel oil there is no bed of coals, therefore sufficient refractory surface must be installed in the fire-box to take the place of the bed of coals and furnish sufficient radiant heat to maintain temperatures high enough to complete combustion. Where there is not sufficient refractory surfaces or where the refractory surface is poorly located, drumming will result.

Refractories

Of utmost importance is the placement of fire-brick or refractory linings themselves, both from an economic point of view in maintenance of refractory linings, as well as their ability to properly direct the flame and best protect the exposed sheets.

In the use of fire-brick of standard size (2½"x4½"x9") it is always best to place the brick with edge or end exposed to the flame. The flash-wall and all bricks upon the shelf of the pan should be placed in this manner.

A late practice in the placement of bricks next to side-sheets, which is proving advantageous in the protection of the sheets next to the mud-ring, is to make the height approximately 18" from the shelf of the pan or four rows of brick 4½" high. In so doing the surface of the sheet is covered higher, but tests to date on the same locomotives equipped with brick 9" above the mud-ring show no difference in fuel economy over a period of more than six months, but do show materially less deterioration of the sheet at the mud-ring end. In support of this is the fact that the mud-ring is a dead end and a settling space for sediment, as its name implies, and being a settling chamber should be treated as such and protected by carrying the refractory higher than has heretofore been the practice.

Some oil-burning authorities never sacrifice a square foot of heating surface in the fire-box wherever possible to secure it, whereas the supporters of carrying the refractory high on the side-sheets claim that the heating surface closely adjacent to the mud-ring is of little value. One thing is certain by the new arrangement, and that is, that engines will not be in the back shop as often by far for new side-sheets with the high refractory setting.

Front End

There has been considerable speculation as to the removal of baffle-plates from superheated locomotives using oil as fuel. One road reports no apparent deterioration of superheater elements, although the baffle-plates were removed from these oil-burning locomotives two years ago. It is the purpose of these baffle-plates to prevent gases from passing through the superheater flues while the engines are being fired up and standing and also give a more equal distribution of the gases between the upper and lower portions of the evaporating surface and superheating surface. With the baffle-plates removed the natural tendency is for the gases to flow through the top flues where less restriction is offered. On some of the engines which have had the baffle-plates removed a longer downward extension stack has been applied, which in a measure helps to baffle gases passing through the top flues, creating a condition similar to that where baffle-plates were in use. With baffle-plates removed it is much easier to keep the flues clean, as they take sand more readily. It is also easier to fire up engines without forcing and making black smoke. It also means one less item of maintenance. It is no doubt a fact that the removal of baffle-plates from oil-burning locomotives would be more advantageous and that less damage would occur to the superheater elements than on a coal burner.

I accepted the invitation to prepare this paper with but one idea in mind: to make you think seriously of the many problems involved in securing the maximum efficiency from every gallon of oil burned in a locomotive and if through your effort just 1% of the annual bill for fuel oil ($73,800,000 last year) can be saved, my efforts will not have been in vain.

The report was signed by J. N. Clark of the Southern Pacific Company.

Maintenance of Brake and Train Air Signal Equipment

The American Railway Association, Division V Mechanical, has sent out a notice to the member companies calling attention to the rules and regulations that were adopted as standard in 1923 for the operation and maintenance of air brakes and signals. These were printed in pamphlet form by the association under the date of February, 1924, and they cover all of the work to be done, in the two departments of operation and maintenance. The circular accompanying the pamphlet is dated September 22, 1924, and is as follows:

Your attention is especially called to the report of the Interstate Commerce Commission on their "Investigation of Power Brakes and Appliances for Operating Power Brake Systems" and to the following paragraph in that report relating to maintenance:

> "Throughout this proceeding the necessity for better maintenance of present power-brake equipment in order to secure proper operation and safely to control trains was repeatedly stressed, and this necessity was recognized by both carriers and employes. It is beyond question or argument that piston travel should be maintained within proper limits, triple valves should be kept properly cleaned, brake-pipe and brake-cylinder leakage should be kept below certain prescribed amounts, and retaining valves with their pipe connections should be kept in good condition; furthermore, rules should provide and proper tests should be made to insure that trains will not leave terminals with defective, inoperative, or cut out brakes on any cars."

In a letter from the Acting Chairman of the Commission, attention is further called to this feature in the following paragraph:

> "Definite suggestions are made in the report as to improvements in the operation of existing brakes which can be effectuated by the carriers, without awaiting formal action by us."

The Mechanical Division of the American Railway Association has prepared from time to time recommendations as to the maintenance of power brakes and train air signal equipment, has recently revised these rules and adopted them as standard, your company being a party to this proceeding, and in February, 1924, issued them in booklet form.

In view of the evidence introduced at the power brake hearing with relation to the lack of uniformity and the failure to properly maintain brake and air signal equipment, copy of specifications for maintenance is sent you with this letter, with the advice that as many additional copies as you may desire for distribution will be furnished, at cost, by the Secretary on application. It is further suggested that a copy of these rules be placed in the hands of all those responsible for this class of work with appropriate instructions regarding their adoption and observance.

Great Northern Railway to Electrify 80 Miles

The Great Northern will soon begin to prepare for electric propulsion on an 80-mile section of its line over the summit of the Cascade mountains, according to an announcement by Vice-President L. ,C. Gilman, at Seattle, Wash. The line between Wenatchee, Wash., and Skykomish will be the first to be electrified. Power will be furnished by the company's power plant to be installed on the Chelan river. The site has already been purchased and plans have been made to construct a generating station capable of supplying power for the entire electrified line.

Plans for the electrification of the line between Spokane and Seattle were made before the war, but construction at that time was postponed because of the high cost of labor and materials. With the return of more normal conditions, the work is to be pushed to completion.

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Can't We Let Well Enough Alone?

A number of years ago there was a hearing before a committee of the Maine legislature on a bill that was pending to compel the street railways to adopt a certain type of equipment. The bill had been proposed by a member who was a dentist. When asked to present his argument in support of it, he said that he had been a member of the legislature for two years and had never before presented a bill, and for that reason would like to have it passed; besides which he thought it embodied a good idea.

Sometimes it seems as though a good deal of proposed legislation rests upon about the same basis, though more frequently there are indications of the ominous presence of a bloc behind it.

This seems to be the case with the bill now before Congress to do away with the Labor Board and substitute in its place four national adjustment boards, without authority, without legal standing, and as Jacques once said, "sans teeth, sans eyes, sans taste, sans everything," except perhaps the power to add another burden to the taxpayer, for it is estimated that this will amount to about one million dollars a year. And of what use? The present Labor Board has the power in the event of any controversy affecting wages to require the parties in the dispute to appear before it, investigate the situation, reach a decision and make a report informing the public as to that situation; the public which is now adequately represented. And now it is proposed to give the public no representation on the adjustment boards, but leave matters to their tender mercies with an equal representation of labor and the railroads, and with about the same prospects of an amicable adjustment as that of two Kilkenny cats tied by the tails and thrown across a line. One congressman aptly called it "The Resumption of Strikes Bill."

Practically this same condition existed in 1919 during government control, and the record of strikes of that time is appalling, while for the past four years, under the operation of the Labor Board, there has been a welcome relief from such upheavals.

Then there is the attempt to repeal the Transportation Act, on the false plea that it guarantees an income to the railroads, or anything to gain the farmer vote. It must be conceded that farmers and banks in the northwest are in a perilous state, but why put the burden upon the railroads, when the most casual investigation will show it to be the result of wild-cat banking and borrowing; of men launching out and assuming responsibilities far beyond their capital capabilities. But the railroads, like the poor, being always with us, they are a convenient target.

The point is that, under the rulings of the Labor Board and the operation of the Transportation Act, the railroads are beginning to get on their feet, even though a little wobbly, after the debacle of government control, so why not, in the name of all that is good and proper, keep hands off for a while and give them at least a fighting chance to recuperate.

The Traveling Engineers' Association

A substantial portion of the present issue of Railway and Locomotive Engineering is given to the publication of the reports, papers and addresses at the Convention of the Traveling Engineers' Association.

Thirty-two years ago a group of traveling engineers met in the office of this publication in New York and, raising the motto, "To Improve the Locomotive Engine Service of American Railroads," formed the Traveling Engineers' Association. After a study of the work done at its various conventions we do not think that any subject of investigation that covers the motto adopted has been neglected, and we have always been glad to record the valuable contributions and notable work of this association for the improvement of locomotive engine service.

One of the greatest expenditures of a railroad is for fuel, and the association, recognizing the importance of this item of expense, its conservation is constantly the subject of investigation report and discussion by the organization. At the convention last month a committee of which Wilson E. Symons, Associate Editor of Railway and Locomotive Engineering was chairman, presented a report under the title of "Conservation of Fuel, Both Oil and Coal, and the Feed Water Heater." This paper is a valuable compilation of data previously published combined with the answers to a questionnaire sent out by the committee.

This questionnaire covered the points of the purchase of fuel, the records of its issuance and use, and inquiries as to the use of feed water heaters and other fuel saving appliances.

The report opened with a general resume of the world's supply of fuel and the rate of its consumption together with a statement of the position of the United States in the matter both as to supply and demand.

The suggestions made regarding purchase, storage and recording of fuel supplies were:

1. The prime or controlling factor in the purchase of locomotive fuel should not be to see how many gallons or pounds can be purchased for $1.00, but to first determine as to the suitability or fitness of the fuel in question, and, second, to know definitely that the real value in British thermal units contracted for is received.

2. That the quantity in storage or reserve should be ample to protect against labor trouble, car shortage, etc.,

and that loss from handling, pilfering or spontaneous combustion be amply guarded against.

3. That the system of records or accounting be such as to clearly draw the line of demarkation between all subdivisions of fuel, so as to show definitely and clearly the exact amount used in producing ton miles and passenger car miles.

The scientific phases of coal storage, and the conservation of fuel oil, in which the storage and issuance of fuel is treated as well as the fuel records; a system of educating the engine crews in the economical use of fuel; fuel saving devices and the effect of lubrication on fuel economy.

Portions of the report were based on articles contributed by the chairman of the committee to the columns of RAILWAY AND LOCOMOTIVE ENGINEERING.

This statement holds for the chart showing the locomotive performance on forty railroads which was published in the February, 1924, issue, which also contained the resume of locomotive improvements and the indicator diagrams from passenger locomotives showing the effect on excessive back pressure by the use of a variable exhaust. This was supplemented by extracts from a second and third article published in March and April, 1924, and in September, 1924, the table showing the results of the fuel economy campaign. Readers of this paper who have followed the matter for the past year or more are therefore familiar with the method of analysis and some of the details of the report.

In its summing up the committee stated that the indications were that a saving of from 15 to 20 per cent could fuel and 35 per cent in steam when operating under maximum sustained load; the birch arch with 10 per cent, and the exhaust steam injector with from 5 to 15 per cent. To these may be added such other possible sources of saving as pneumatic firedoors, thermic syphons, boosters, mechanical stokers and the education of the crews, so that with a total fuel bill of $617,800,000 there is a possible saving of ahout $61,780,000.

The New Haven Machine Tool Exhibit

During the week of September 15th a machine tool exhibition was held in Mason Laboratory of the Sheffield Scientific School of Yale University at New Haven, Connecticut, that was well worthy of the attention which it received. It was the fourth of its kind that has been held annually since 1921. It was under the auspices of the New Haven section of the American Society of Mechanical Engineers, Yale University and the New Haven Chamber of Commerce.

The number of exhibitors and visitors have grown from year to year, until now it is attracting attention throughout the whole territory of the country east of the Mississippi River. This year there were one hundred and ten exhibitors, with exhibits covering a wide range of machine tools, and with a marked tendency towards machines adapted to special purposes in production work. This was a very marked characteristic of what was shown. Many of the machines were at work on the production of small articles in large quantities.

Another interesting feature was the universal use of the individual motor mounted upon each machine. There was, of course, no opportunity for the erection of lines of shafting, and so machines without the individual drive were barred from being exhibited in action, but the great variety of machines that are so equipped show to what extent the electric motor has supplanted the old methods of operation.

Lathes, radial, standard and sensitive drills, boring machines, turret lathes, hand tools, micrometers, screw machinery, milling and grinding machines, welding outfits, cold saws and ball bearings were among the list of things that were to be seen. As for workmanship, everything there was an example of the best.

The exhibit was held in Mason Laboratory. All of the equipment of the physical testing laboratory on the ground floor had been removed to the basement leaving a large floor space in a well-lighted room with high ceilings available. In addition to this the balcony of this room as well as several large rooms on the third floor were filled.

In connection with the exhibit, there was a series of meetings at which papers on technical subjects were read and discussed. At the opening session on Monday evening, Mr. G. K. Burgess, director of the Bureau of Standards in Washington, read a paper on the Relation of the Government to Machine Tool Industry. This was followed on Tuesday, Wednesday and Thursday, by papers relating to research in machine shop practice, the application of ball bearings to machine tools industrial education, standards and standardization, and ordnance material. All of these meetings were well attended.

The exhibition was also made the occasion for the meetings of several of the committees functioning under the procedure of the American Engineering Standards Committee. These committees were those on the cutting and forming of metals; small tools and machine tool elements; tee slots, tool holders and tool post openings; gaging manufactured material and gages and their limits.

Finally it is of interest to note that very little solicitation was required in order to fill the space available in the exhibition hall. Manufacturers have applied for space of their own volition, and although there is little or no buying and selling, they evidently regard the display as a good advertising medium. This value is especially emphasized by the growth of the exhibition from year to year since its inception in 1921.

While there was comparatively little that would interest the man engaged in railroad repair work there were some things that had such a direct bearing on that class of work that they will be illustrated and described in a future issue.

And finally a point to be kept in mind is the attitude of approval given by manufacturers, and their evident consideration of such exhibitions as paying propositions.

Adequate Transportation

Let us take these steps to get adequate transportation and not complain about it.

Take the railroad situation out of politics. Transportation is an economic question.

We hobble the Interstate Commerce Commission by too many laws and political pressure. They are judge, jury and high executioner, and to prove their impartiality, Congress and a large part of the public have heretofore insisted chiefly on the latter qualification.

Why not pay these hard working Commissions well; insure them a proper tenure of office, but insist that like the heads of other Governmental Departments they must insure adequate transportation service?

Why retain Commissioners whose chief duty and chief recommendation, until quite recently, was to publicly disparage the railroads, starve them into submission, and be hostile to the present system of ownership by our citizens?

Let us try a Secretary of Agriculture whose chief duty is to disparage agriculture and restrict the farmers' earnings.

Let us have a Secretary of the Treasury whose chief recommendation is that he knows nothing of finance, and disparages the whole monetary system because it is the product of capitalism.

The load of Federal and State legislation is too restrictive and costly.

Let the farmer, the banker, the business man and the steady working man realize that inadequate railroad transportation and facilities are hurting him; and let him inform his Senator and Representative in Congress that the Country does not need 134 new railroad laws.—*A. J. County, Vice-President, Pennsylvania Railroad System.*

Another Point in Favor of the Outside Dry Pipe

EDITOR RAILWAY & LOCOMOTIVE ENGINEERING:

In your description of the outside dry pipe used on the Mallet locomotives of the Kansas City Southern Ry., and your comments on the advantages of the same in your September issue, you neglected to mention one that is of considerable importance.

One of the substantial benefits derived is the increased steam space in the boiler that results from the removal of the large dry pipe.

As you are aware, in the modern locomotive the factor of restricted steam space and of entrainment of water with the saturated steam as it passes into the dry pipe is something that is giving a great deal of concern, particularly as it results in the superheater being called upon to do a large amount of re-evaporation and which necessarily reduces its efficiency as a superheater. Likewise the water passing over into the superheater header elements with the saturated steam causes a great deal of damage to those parts. Therefore, anything that can be done to increase the steam space in the boiler and to insure dry saturated steam entering the superheater header is of great benefit. X.

Mean Effective Pressure in Engine Cylinders

The curves shown in the accompanying diagram are based on the coefficients of average pressures for pistons moving at different speeds in locomotive cylinders of ordinary dimensions, for both simple and compound locomotives.

The upper curve gives the coefficient for simple engines, and the lower curve for the low pressure cylinder of compound engines when the volume of the low pressure cylinder is 2½ times that of the high pressure cylinder.

The coefficients indicated are those by which the boiler pressure is to be multiplied in order to obtain the mean effective pressure.

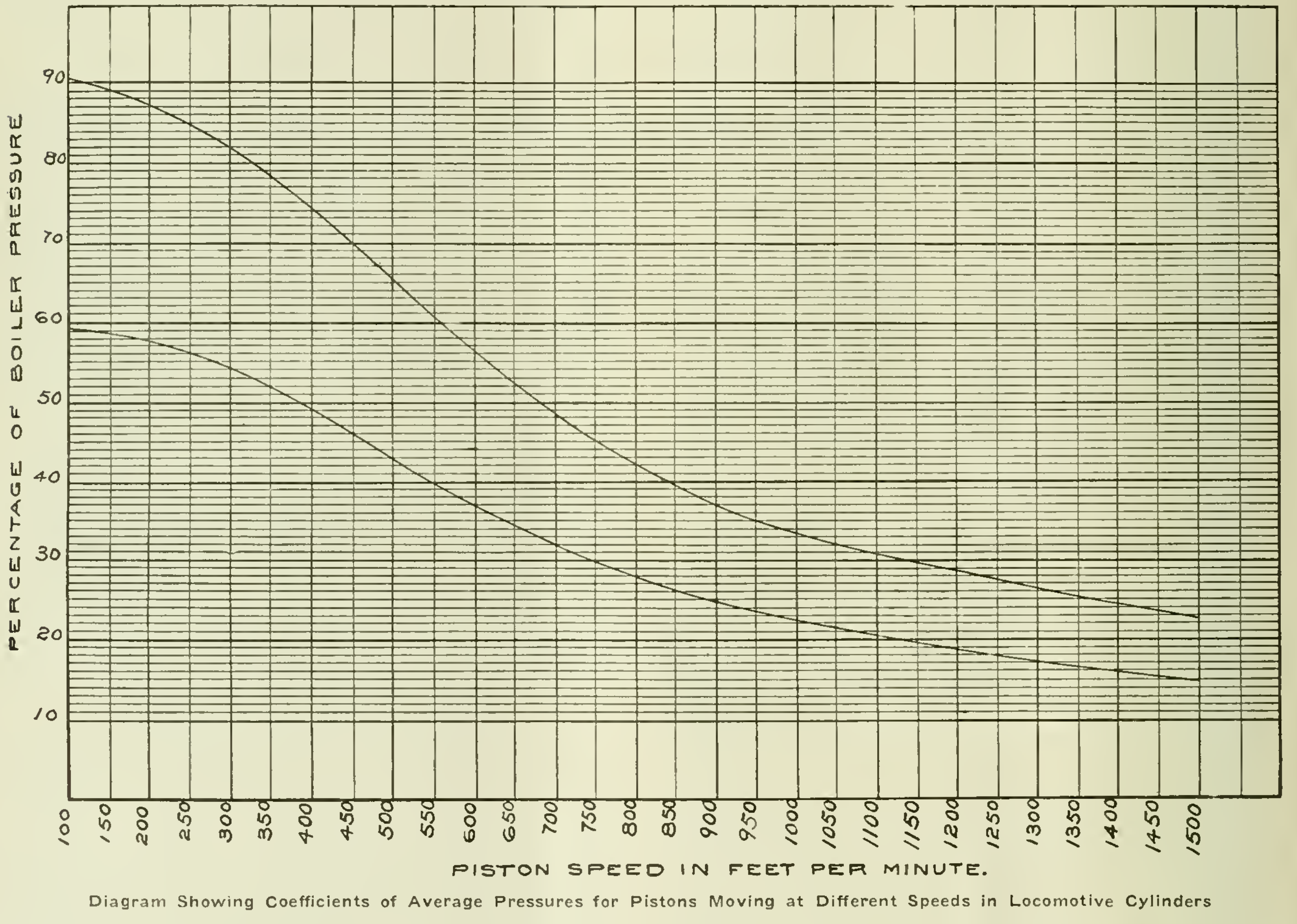


Diagram Showing Coefficients of Average Pressures for Pistons Moving at Different Speeds in Locomotive Cylinders

In the case of compound locomotives the mean effective pressure of the high pressure cylinder is obtained by taking the distance between the two lines.

For example, taking a piston speed of 900 ft. per minute and a boiler pressure of 200 lbs. per sq. in.

The coefficient for the simple engine cylinder is .37 so that the mean effective pressure in that cylinder will be 74 lbs. per sq. in. That of the low pressure cylinder of a compound locomotive is .247, giving a mean effective pressure of 49.4 lbs. per sq. in.

The curves must, however, be regarded as approximate only, for evidently they depend quite as much upon the point of cut off as on piston speed.

Operating Economies Augmented By Long Engine Runs

By W. E. SYMONS

At the annual Convention of the Traveling Engineers' Association recently held in Chicago, Ill., there was among other committee reports a very exhaustive treatment of the subject of Conservation of Locomotive Fuel, Both Coal and Oil, and the Feed Water Heater. In summing up, the committee estimated the possible total savings at about $72,919,200.

Fuel Used at Terminals

In treating the item of terminal fuel for locomotives, the committee report stated: "About 20 per cent of the locomotive fuel is used at terminals by roundhouse or shop forces, the amount so used being about $111,200,000. We feel that with farther extension of *"long engine runs,"* hot water boiler washing systems, better housing and repair facilities, more care in firing up in roundhouses, and reduced delays in holding live engines for assignment to trains, should result in a saving of from 15 to 20 per cent in locomotive terminal fuel. $111,200,000 × 15% = $16,680,000."

It will be observed that the committee gave endorsement to the benefits derived from long engine runs and suggested that the practice be extended and thereby effect still greater economy in fuel, and while the question of running repairs was not specifically mentioned, as it might be considered outside the scope of the committee's work, it was no doubt assumed that extending locomotive runs effect other economies than in fuel alone.

Pooled Versus Assigned Engines

Following the introductions of pooling engines several years ago, there was much controversy and discussion of the relative merits of the pooled and assigned systems of handling power, but with few exceptions it now seems to be the general accepted plan to follow the pooling system as the most economical from all standpoints.

A representative of one of our best managed trunk lines, however, differed with the committees' recommendations as to economies resulting from long locomotive runs, explaining in detail his reasons therefor.

We quote herewith the remarks of the dissenting speaker on this subject.

"The paper recommends extending long locomotive runs. One of the previous speakers told us of some that had been very successful in effecting a saving by long locomotive runs. Possibly he meant fuel; possibly other savings.

"After listening to the paper and the talks, the natural conclusion anyone would have drawn was that the quickest way for a railroad to make a lot of money, by obtaining much greater service from their engines and at lower cost, would be to immediately begin running them over several divisions. But, before recommending such a proposition to the management of the road with which I am connected, I decided to look into the performance of various railroads which have been widely advertised in the various railway publications as having accomplished great things by running engines over several divisions, to find out in just what respect their handling of power was superior to ours, which is locomotives assigned to run only on each division, and engineers and firemen assigned to regular engines, some passenger runs being what are termed "blanket runs" which extend over two divisions, a total of 235 miles, but the engineer and fireman assigned to the engine running through with it. This has been the practice of the road with which I am connected for many years. Through all the clamor and propaganda purporting to show the benefits of pooling engines, we have held steadfast to the policy of assigned engines to regular engineers.

"The same argument that has always been advanced in favor of pooled engines is now advanced in favor of running engines through over several divisions, i. e., that railroads have a lot of money invested in a locomotive; the locomotive only earns money when it is making miles; it earns nothing standing still. If this money invested in locomotives is to earn the heaviest return it must be kept moving. Therefore it is a poor policy to let it stand idle while an engineer is taking his rest, or, in the present proposition, to let it stop at a terminal at all so long as it can be kept moving.

"The premises of this proposition are sound. I fully agree that engines only earn a return on the investment while they are moving and that any comparisons drawn should be based on the average miles per engine, per year, obtained by any railroad. But the conclusion so many railroad men have reached, that pooling engines,—or running engines over several divisions, which is also the same as pooling, whether or not they are assigned to certain runs,—is the way to obtain the greatest mileage, is entirely wrong as I will prove beyond a doubt by comparative figures.

"The reason so many have been misled on this proposition is because the advocates of pooled engines, or long runs, in presenting locomotive mileage figures have not taken into account the engines lying idle receiving repairs, or awaiting repairs. They lose sight entirely of the fact that any locomotive requires a certain amount of maintenance, and this amount increases in proportion to the lack of interest taken in the machine by the engineer; and every one of you know that engineers operating pooled engines take very little interest in them, while engineers with regular engines look upon them the same as personal property. The increased maintenance required for the pooled engines means more idle time.

"After all the smoke of arguments in favor of long runs has cleared away, such as reducing forces required to turn engines, fuel saved firing up, etc., which is all theoretical,—the reduction in forces being an insignificant factor and the fuel saved firing up being offset by excess fuel used maintaining steam pressure with clinkered fires,—the only real object remaining for running engines over several divisions is to reduce the number of engines required on a railroad, or, in other words, increase earnings on the investment in each locomotive. To find out how this works out in practice, the only way to determine what is actually accomplished is to consider the total locomotive miles and total locomotives on any railroad in a given year, and then determine the average miles per locomotive per year. This comparison will disclose the actual accomplishments under various systems of handling power, whereas citing a few engines on a few runs determines nothing. You will, no doubt, be surprised to learn that upon drawing a comparison between our road, operating engines assigned to regular engineers and to one division, with several other roads operating engines over several divisions, and pooling them, I found that during the years 1922 and 1923, we on our lines obtained more miles per engine, and at a lower maintenance cost, than any of the others as the following figures will show.

It would probably not be ethical to read the figures, but I have them here. They give the railroad, engines owned, total locomotive mileage in 1923, average miles per engine per year and maintenance cost per engine mile. On the lowest of these the cost for maintenance was $.2653,and the highest in those roads was $.3705. The highest miles per engine per year was on our lines with 32,436, and the lowest of the roads was 22,744.

"This proves conclusively that the road with which I am connected not only earned a greater return on its investment in locomotives, but also in addition saved a large sum on maintenance, as during the year 1923, had the maintenance cost been as great as the lowest of the roads compared with, it would have cost our lines $1,805,668.36 more to maintain its locomotives than it did cost, and had the maintenance cost been as great as the highest compared with, it would have cost $6,107,919.99 more.

"I have always been against pooled engines, and running engines over several divisions means pooled engines. The so-called assignment of certain engines to certain long runs is a farce, as seven or eight men running four or five engines is pooling engines just the same as thirty or forty freight engineers running fifteen or twenty freight engines in pool freight service.

"In the light of these facts, I do not see how any one could consistently say that our road would benefit by pooling their engines and running them over several divisions. If any of you think that because the maintenance costs I have given, showing a saving of several million dollars as compared with other roads, indicates that our engines are not maintained in as good a condition as those on any other road in the country, you are invited to visit us and ride any of them with me, and inspect their condition and performance yourself."

Regularly Assigned Engines Satisfactory

From the foregoing it is clear that the system of regularly assigned engines and crews on the particular railway system referred to is giving satisfactory results.

We still believe however, that much saving has been effected, and that more can be effected by an extension of long runs, and that while it has certain disadvantages, these are more than offset by its merits, which when interpreted in money seem to fully justify the action of those who have adopted it.

In the August issue of RAILWAY & LOCOMOTIVE ENGINEERING, we published a paper on Long Locomotive Runs, by Mr. Frank Russell, Asst. Mechanical Engineer of the Southern Pacific Company, in which the numerous advantages are explained in detail. The names of some fifteen trunk lines with long runs are given in dollars and cents. The results shown are most convincing.

In view of the wide divergence of views held, and the expressed doubts of some, as to the merits of the two systems we present in tabulated form statistical data of fourteen different railways. Thirteen of these lines have extended freight or passenger runs or both, while one line, the fourteenth in number has not. This road still has regular assigned engines and crews, which it claims is far more economical than the pooling system.

The table which follows will furnish much food for thought and study by those interested in the subject and particularly those who may not agree that the pooling and long locomotive run system does not yield the returns claimed for it.

A few points might be mentioned in which the deductions from this table differ from the figures favorable to regularly assigned engines and crews.

On the railways numbered one to thirteen and having long locomotive runs, there is a total of 17,808 locomotives and 4,035 of these or 22.6 per cent were either unserviceable or stored awaiting traffic demands. On the railway numbered 14, there were only 234 or 12.36 per cent out of service. Railway numbered 6 has only 9 per cent of engines idle, with running repairs less than 20 cents per mile and on a basis of the cost per 1,000 pounds of tractive power of only $20.60 per 1,000 lbs.; which might be considered a very strong endorsement of long runs.

W. E. Symons - Oct. 1924.

Roads by Number	Long Runs in Miles		Engines, Mileage & Cost of Repairs					Tons Per Train, Coal Per 1000 Ton Miles & Earnings Per Frt.& Pass. Trn. Mile			Earnings Per Pass. Train Mile	Average Miles Per Engine Per Day		No. Engines Unserviceable and Stored	Average Tractive Power & Cost Per 10 00 Lbs. T.P.	
	Pass.	Frt.	No. Engines	Miles Run Per Engine	Miles Per Engine in Service	Repairs Per Eng. in Serv.	Repairs Per Mile ¢	Train Load Tons	Coal Per 1000 Ton Miles	Earnings Per Frt. Trn.Mile		Frt.	Pass.		Average Tractive Power	Cost Per 1,000 Lbs. T.P.
1.	602	310	1,782	30,368	39,993	$10,059	27.7¢	579	148	$6.88	$2.97	94.1	169.7	427	43,480	$23.15
2.	360	278	2,556	28,623	36,251	9,770	26.9	840	188	8.01	2.20	86.9	159.7	539	45,584	21.52
3.	321	209	2,022	26,132	32,052	6,824	21.3	645	160	5.91	1.99	75.5	128.0	373	36,358	18.76
4.	542	251	941	28,604	36,595	10,773	29.4	464	194	5.67	2.62	83.6	153.7	205	37,792	28.36
5.	526	202	1,427	23,233	32,139	5,678	17.6	814	150	7.62	1.91	69.3	132.8	395	40,682	13.97
6.	400	189	3,940	28,605	41,155	8,229	19.9	899	134	8.43	3.56	90.9	152.0	358	40,285	20.60
7.	370	260	181	25,159	39,137	7,197	18.3	464	136	6.65	2.13	92.4	165.4	64	27,130	26.52
8.	430	160	186	28,091	33,347	9,939	29.8	774	139	8.08	2.24	87.9	201.0	29	43,391	22.90
9.	678	278	643	21,784	44,207	10,202	29.1	589	148	7.17	2.33	98.9	195.6	321	39,887	25.57
10.	338	208	1,126	29,686	41,539	11,111	26.7	633	162	6.28	2.07	94.2	172.8	320	36,264	30.66
11.	815	387	1,498	33,816	42,280	9,007	21.3	661	147	8.39	2.60	96.8	169.5	299	38,350	23.48
12.	740	453	559	30,590	41,694	10,178	24.4	559	128	6.32	2.64	105.7	199.0	148	32,540	31.24
13.	577	303	947	32,749	47,613	10,029	21.0	640	153	6.30	2,25	144.8	224.7	293	43,619	23.00
Tot. & Aver.	515	262	17,808	28,232	39,077	8,153	24.1	658	152	7.05	2.42	90.	171.	4,035	38,874	23.82
14.	235	117	1,892	32,209	36,770	8,545	23.2	764	148	5.93	2.16	91.4	143.9	234	38,948	21.94

Statistical Tabulation of Fourteen Railways—Thirteen with Pooled Engines and Extended Long Runs Over Two or More Former Divisions. One Line Number 14 Has Regular Assigned Engines and Crews

The number of engines out of service does not necessarily reflect the standard of maintenance for all lines for the reason that engines in bad order awaiting or undergoing repairs are combined with those stored in good order awaiting traffic conditions requiring their use. On some lines engines stored and in good order is as high as 14.3 per cent. The total stored engines on one line being 334, while on another line with less than 1,000 engines, 142 or 15 per cent are stored ready for service.

Second: It is worthy of note that on six lines, the cost per mile is less than the average of 24 cents, and also lower than road number 14, which is only 23.2 cents. We may add that five of these roads operate over heavy mountain ranges embracing about the most difficult and expensive conditions in the U. S. Those roads that have adopted the long-run-pooled-engine plan claim economies resulting therefrom on the following items:

A. Increased engine mileage ranging from 30 to 100 per cent.

B. Reduction in number of locomotives for a given service ranging from 25 to 40 per cent of the power.

C. Appreciable increase in capacity of complete transportation unit.

D. Marked economy in terminal and roundhouse expense at cut-out points with only slight increase at new terminal, resulting in a very substantial *net* saving.

E. A very substantial and definite saving in fuel on the items of dumping and rebuilding coal fires and a corresponding reduction in fatigue strain to boilers, due to cooling down and firing up.

On one of our transcontinental lines with heavy passenger power in mountainous country there are six long passenger runs that average 554.3 each and as a result of extending both freight and passenger runs it is estimated about 70 engines have been released for other service. Placing a value of only $25,000.00 on these engines means $1,750,000.00 of new capital or its equivalent to this company.

From the foregoing table it will be observed that the average earning per freight train mile is $7.05 and per passenger train mile $2.42 and that there is a total of 17,808 locomotives on the thirteen railways that have found most satisfactory results, with substantial saving both in expenses and capital investment from the long-run-pooled-engine plan. It is felt that the committee was well justified in committing itself to this plan and recommending its farther extensions.

As an example or hypothetical case let us take 1,000 locomotives, 60 per cent freight and 25 per cent passenger, less 15 per cent for shopping equals 510 in freight and 213 in passenger service.

If by extending both freight and passenger runs and pooling engines even 20 per cent of power could be released for other service we would have the following results:

102	freight engines $20,000 each......	$2,040,000
42	passenger engines $30,000 each....	1,260,000
144	engines released	$3,300,000

The marked increase in annual earnings for each remaining freight and passenger engine following release of the above, or even a lesser number, plus the saving in terminal expense, fuel, etc., would justify an increase in maintenance expense due to increased mileage, etc., and still leave a *net balance* in favor of the long run plan.

We are open and receptive to all information available on this most important subject.

The Modern Power Plant on Wheels

By L. G. PLANT

The design, operation and maintenance of motive power should be governed so far as possible by four fundamental objectives. First: dependable design and reliable operation. Second: efficiency in operating cost and capacity. Third: maximum output of the most efficient motive power units. Fourth: economy in the maintenance of locomotives in a dependable, efficient and productive condition.

Dependable power has always been regarded as the most vital requirement upon the motive power department. The consequences of a failure on the road are such that in locomotive construction and subsequent maintenance, operating reliability is the first consideration. No feature in design however efficient, nor maintenance practice however economical will ever be tolerated on American railroads if it impairs the ability of the locomotive to "get over the road." Those who have sought to improve motive power efficiency by the application of auxiliary devices have found that they must first provide equipment that can be depended upon to function reliably.

No saving in the cost of operating locomotive shops and terminals will justify engine failures resulting from too rigid economy in their maintenance. Nor can the time that locomotives are available for service be increased at the expense of time actually required for maintaining these locomotives in a dependable operating condition. Any permanent improvement in locomotive output must be based upon sound operating methods and better facilities for maintaining motive power in a serviceable condition.

Next to reliability in locomotive operation comes efficiency. Locomotive efficiency implies more than a relation between output and the fuel consumed; it includes capacity, both in respect to the investment involved and the size and weight of the locomotive itself. Efficiency in locomotive design and condition is the next most important requirement upon the motive power department.

Efficient motive power is not only essential because it affects the cost of railway operation but also because the capacity of the railroads is governed by the individual efficiency of its locomotives. Eliminate all of the many improvements to locomotive efficiency that have come into general use in this country within the last twenty-five years, and you will then realize the impossibility of handling present day traffic on existing lines. Increases in tractive effort have not resulted from a mere enlargement in the size of locomotives but principally from more efficient design.

It has been said that our large cities could never have grown to their present size without the mechanical reaper which enabled the harvesting of crops in sufficient volume to provide for the vast quantities of food required by the millions of people who live in these urban districts. Likewise, it may be argued that improvements in locomotive efficiency have played an equally important part in the growth of this country. As a factor in the future growth of this country locomotive efficiency must be raised to the highest possible average and further improvements secured both in locomotive design and in the facilities for maintaining this motive power.

Maximum efficiency in locomotive performance cannot be realized without obtaining the maximum output from individual locomotives. Locomotive operation should always be concentrated upon the most efficient units and the maximum output continually secured from these locomotives so that the less efficient units can be stored. This practice is an important cause contributing to the substantial reduction in unit operating costs that have been registered by a number of railroads in recent years.

Compare, for example, the situation on the Union Pacific Railroad in March 1924 with January 1920. The gross freight ton-mileage, excluding weight of locomotive and tender, was slightly higher in March 1924 than in January 1920 (January 1920—1,624,860. March 1924—1,629,127), but the volume of freight traffic or amount of work performed by motive power in this class of service is sufficiently similar to afford a good basis for comparison. In January 1920 the Union Pacific Railroad had an average of 371 serviceable freight locomotives, of which only 5 were stored. In March 1924 this road reported an average of 459 serviceable freight locomotives on line but 184, or 40 per cent of these locomotives were stored. In other words, the Union Pacific Railroad produced practically the same ton-mileage in March 1924 with an average of 275 locomotives in freight service that it produced in January four years ago with 365 locomotives in this service.

It is evident that the Union Pacific Railroad could not have effected this large increase in the output of each individual freight power unit without the acquisition of more powerful and efficient freight locomotives. But it is also significant that along with the addition of these new locomotives, the railroad has pursued a systematic policy of storing the less efficient locomotives so that the average productive time of each locomotive in freight service is practically as high as it was when the number of locomotives available for service was considerably less. The Union Pacific Railroad could not have achieved its present state of operating efficiency with all its new motive power in use had it also retained the less efficient locomotives in service and allowed the average output of all freight locomotives to decline. Operating statistics for the Santa Fe Railroad also reflect improvement as the result of a similar policy in respect to storing the less efficient units and maintaining a high average output for the most efficient locomotives. In June of the current year this road had 803 serviceable locomotives out of which 233 serviceable locomotives, or 29 per cent are reported as "being stored."

There is a fixed "over-head" expense attached to every locomotive that continues whether the locomotive is in operation or idle. This "over-head" expense increases or drops with a decrease or rise in the traffic volume and can only be controlled through a policy governing the purchase of locomotives. Where increases in freight traffic have been met by increasing the average output of the locomotives in this service instead of placing proportionally large orders for additional motive power to handle the business, this policy has reduced the "overhead" expense for each locomotive owned. Conversely, there is no greater incentive toward increasing the individual output of locomotives owned than an actual shortage of power and some of the best examples of what can actually be accomplished in the utilization of motive power is afforded by these railroads on which motive power purchases have been restricted as a matter of policy or financial necessity.

The president of a locomotive company was recently quoted as having stated that there were too many locomotives in this country. This has no serious bearing upon the business of the locomotive manufacturers which is primarily that of replacing worn out and inefficient units with modern motive power that will save more than enough in operating costs to absorb depreciation and pay interest on the investment. But this statement is literally substantiated by a study of the actual situation that clearly indicates a greater need generally for expenditures upon locomotive terminals and other facilities for increasing the earning power of existing locomotives than for the purchase of additional motive power.

The greatest obstacle to this policy lies in the relative difficulty of obtaining funds for improvements to mortgaged property in comparison with the ease with which money can be secured for the purchase of locomotives through the sale of equipment trust obligations. A solution to this difficulty is found in the rental of the improved terminal facilities from contractors who are able to install and finance these improvements on this basis.

The problem of increasing the individual output of locomotives has acquired added importance with recent increases in the cost of motive power. The modern locomotive can, in reality, be regarded as a seventy-five or one hundred thousand dollar power plant. What would we be obliged to pay for electric current in any city, if supplied by these separate power plants each operating on average less than eight hours out of twenty-four? To make this parallel complete, let us assume that the fires under the stationary boilers are dumped after each run.

This is substantially the condition applying to the average locomotive, which can be considered a self-contained power plant on wheels. It is possible that if these three power plants were each "assigned" to an individual crew, that these men would take a greater personal interest in their "assigned" power plant, would cultivate more flower beds surrounding the building, keep the brass railings polished somewhat brighter and perhaps reduce the maintenance cost to some extent. But it is apparent that both the operating and investment expense of such an arrangement would increase the cost of electric current to a figure that would not be tolerated in any community.

The same economic laws that govern the cost of electric current generated in a stationary power plant also control the cost of tractive effort at the draw-bar of the locomotive. But the conditions under which locomotives are operated make it impossible for them to maintain in continuous service, at least without radical changes in design and vastly improved terminal facilities. The rack and wear of running over uneven roadbeds and the intensive rates of evaporation in locomotive boilers necessitates withdrawal from service for periodic shoppings.

The American Railway Association now has a committee including both operating and mechanical department officials who have been appointed to deal with the problem of locomotive utilization. It is also understood that a sub-committee is already at work on a study of the situation on various railroads with respect to this problem. An analysis of the methods and facilities on these roads will point the way to a substantial reduction in the non-productive time of locomotives but the subject should always be viewed broadly. The analysis might otherwise become so detailed as to obscure the real issue.

The question of which department is responsible for a terminal delay is not of such consequence as the magnitude of the delay itself. Attempts to register the proportion of terminal detention for which the operating and mechanical departments are separately responsible usually degenerate into a futile effort to see which department is most successful at "passing the buck." The important thing is to keep the most efficient power in operation as much of the time as possible and this is an objective in which both departments are jointly concerned.

There are a number of admirable methods for improving locomotive utilization which the work of the American Railway Association's Committee will emphasize. The most widely advertised practice is the recent extension of locomotive runs. The inauguration of "Main-Trackers" or the continuous operation of freight trains through congested terminals without changing locomotives has undoubtedly contributed to the relatively high percentage of time the freight locomotives are in service on the Baltimore and Ohio Railroad. Another railroad arbitrarily requires its division officials to store a certain number of serviceable locomotives as soon as the average locomotive mileage for the division falls below a standard value.

Locomotive terminal and shop facilities, however, are the determining factors in respect to locomotive utilization and any comprehensive analysis of this problem must take these facilities into account. The effect of maintenance facilities upon the earning power of locomotives is more evident in the design of terminals than in the equipment of large shops. Locomotive terminal facilities not only govern the length of time that locomotives must be held out of service between each run but, with adequate equipment for current running repair work at the terminal, the length of time between heavy repairs for which the locomotive must be sent to the general shop can be materially lengthened.

It has been contended that the cost of making repairs at a number of terminals is generally higher than if this same work were concentrated at a large shop. But if the time that locomotives are available for service can thus be increased, the value of their additional earning ability should be weighed against the higher repair costs involved in making repairs at terminals. Reliability and efficiency in operation are also factors which take precedence over the cost of repairs provided this is not excessive. It is reported that one railroad on which the locomotive performance is particularly good both from the standpoint of operating efficiency and the utilization of motive power, is systematically making running repairs to locomotives each month coincident with monthly boiler inspection and washout.

The necessity for better locomotive utilization will compel improved locomotive terminal facilities that are designed for turning locomotives more rapidly and equipped for reducing the time required for current maintenance and repairs to locomotives. The locomotive terminal should no longer be regarded as a mere shelter for locomotives at the end of the run, means for turning these locomotives and for supplying them with fuel, sand and water. By increasing the output of the most efficient locomotives, the terminal can contribute indirectly, but none the less effectively to locomotive efficiency. There is also a direct economy resulting from improved terminal facilities and some types of terminal equipment can be classed as direct fuel savers, comparable in their effect to any of the numerous economy devices now being applied to locomotives. But in distinction to locomotive appliances, terminal equipment tends to reduce rather than increase locomotive maintenance costs.

No single terminal device has a more direct effect upon locomotive utilization or has greater possibilities for improving the efficiency and capacity of locomotive operation than equipment for washing and refilling locomotive boilers with hot water together with a recent development of this system which provides for steaming up locomotives by the direct injection of steam and hot water. This will enable large locomotives to be filled and steamed up in approximately half an hour and also makes it possible to generate a working steam pressure before the fire is lighted.

This equipment affords a good illustration of the effect of improved terminal equipment upon each of the four fundamental locomotive objects that have been taken as a text for this paper. First, dependability. Dependable locomotive operation is contingent upon clean boilers. This is so essential that the law requires all locomotive boilers to be washed at least once each month irrespective of water conditions. Second, efficiency. A large fuel saving can be made by reclaiming heat contained in the steam blow-off from incoming locomotives and utilizing this to heat the water with which out-going locomotives are filled. It is possible to wash boilers more effectively with hot water and this, in turn, improves their efficiency on the road. Third, output. The time required for emptying, washing, refilling and firing up locomotives with a hot water system is several hours less than without this facility. Fourth, economy. The use of hot water for washing locomotive boilers lessens staybolt breakage, flue leakage and boiler sheet cracks and thus effects a large reduction in the cost of locomotive maintenance. It is stated in the proceedings of the Master Mechanics' Association that on one railroad, the life of locomotive flues practically doubled with the installation of a hot water system for washing boilers.

Economy in the maintenance of locomotives has been referred to as fourth objective although it is generally regarded as the first and most definite requirement upon the motive power department. In fact, the mechanical organization is often controlled entirely from a cost standpoint. This would not be so objectionable if a more logical unit than locomotive miles were applied to maintenance costs.

Ten years ago, it is recalled that only one railroad in the southeast and but few roads in other parts of the country computed fuel consumption upon a gross ton-mile basis in freight service. Fuel was then recorded upon a train-mile basis without regard to whether the figures applied to a 3,000-ton main line freight or a branch line local. All railroads now report fuel used in freight service upon a gross ton-mile basis and passenger fuel consumption upon a car-mile basis. But the statisticians still persist in basing maintenance costs upon the locomotive mile without regard to whether the costs apply to an eight-wheel "Tea-Kettle" on a regular branch line run or to a modern Mikado in a main-line pool. Unlike other necessary improvements, intelligent accounting does not require a large expenditure. True economy in locomotive maintenance cannot be achieved until the expenditures for this purpose are judged by a proper standard.

The four fundamental objectives in the design, operation and maintenance of motive power are: Dependability, efficiency, earning capacity and maintenance economy.

Locomotives in Good Condition for Heavy Fall Traffic

The locomotive equipment of the railroads on September 1st was in the best condition to meet the seasonal fall increase in traffic that it has been since early in the year, according to the Car Service Division of the American Railway Association in a report covering the locomotives serviceable for traffic and those undergoing repairs.

On that date, they had 53,618 serviceable locomotives, an increase of 726 over the number reported on August 15th, and the largest number reported at any one time since January 1st this year when there were 54,031.

The railroads on September 1st also had 6,762 serviceable locomotives in storage, ready for use whenever traffic conditions warrant. This was, however, a decrease of 164 compared with the number in storage on August 15th.

During the last half of August 33,178 locomotives were repaired and turned out of the shops, an increase of 4,703 over the number repaired during the first half of August.

As a result of this increased activity on the part of the railroads in preparing to handle the usual increased fall traffic, the number of locomotives in need of repairs on September 1st totaled 10,964 or 17 per cent of the number on line compared with 11,623 or 18 per cent on August 15th, a decrease of 659.

Locomotives in need of classified repairs on September 1st totaled 6,023 or 9.3 per cent, a decrease of 370, compared with August 15th, while 4,941 or 7.7 per cent were in need of running repairs, a decrease of 289 compared with the same preceding date.

The Pennsylvania Railroad and the Great International Exposition

The Liberal Policy Pursued by the Railroad for Almost Half a Century

By GEORGE L. FOWLER

The Pennsylvania Railroad has always been very liberal in the appropriations which it has made for participation in International Expositions. The first with which it was closely associated was the Centennial Exposition held in Philadelphia, Penn., in 1876. We have seen in the October, 1923, issue of RAILWAY & LOCOMOTIVE ENGINEERING the part played by the road in the handling of the unprecedented traffic that was put upon it during the eight months of the preparation and continuance of the exposition. So notably was its work, that in his official report the Hon. Francis A. Walker, chief of the Bureau of Awards wrote, that the Pennsylvania Railroad was "itself the noblest product of American skill exhibited at the Centennial," and that it "contributed most of all to make success possible."

While the road made no individual exhibit at the exposition itself, it did come in at the close with a subscription to the fund that was raised to establish a permanent exhibit in the art building known as Memorial Hall.

The value of such an exposition as a means of exploiting the facilities of the road was undoubtedly firmly impressed upon the maangement in 1876, for when the French Centennial Exposition of 1889 was proposed the directors took immediate action to be properly represented by a suitable exhibit. In taking this step, the management of the whole matter was placed in the hands of Theo. N. Ely, who from that time on had charge of the Pennsylvania Railroad exhibits at the international expositions held at Chicago in 1893; Paris in 1900; St. Louis in 1903 and Norfolk (the Jamestown Exposition) in 1907.

At the exposition in 1889, the Pennsylvania Railroad was among the first to carry an exhibit of American rolling stock to Europe, and while it was not alone in making a display at that time, it was among the leaders. Viewed from the standpoint of what it has done since, the exhibit in 1889 was small but it was a novel move at the time. It showed passenger and freight car trucks which were then a novelty in Europe; and sections of passenger and freight cars, which, as a type were just beginning to be considered on the continent, while the section of the gondola car shown was new to the European visitors. Probably the portion of the exhibit that was as distinctly American as any other was to be found in the various specimens of the cast iron wheels sent from its own foundry. There were the perfect wheels on their axles, and wheels that had been worn out in service, together with others that had been spoiled in the casting. To this were added a number of broken wheels to show the character and depth of the chill. These with a sample of the standard rail and joint, and some other articles comprised the exhibit of objects. But of equal importance and value to those who chose to look, were the albums containing those specifications for materials which were already making the Altoona testing laboratory famous, and that containing photographs of cars and locomotives which showed the character of the rolling stock used on the road.

In 1900 when the method of American Railways had become more familiar to the foreign engineers, and there was a more elaborate display on the part of the manufacturers of the United States, the exhibit of the Pennsylvania Railroad was greatly limited and was confined to photographs and printed matter. But even these showed the broad gauge interests of the road. There were shown a series of photographs of station grounds in the department of horticulture and arboriculture. Then there were shown a very complete set of reports, charts and photographs of the work of the relief association on the organization of which the Pennsylvania took the lead among American Railways. These cases are cited to show the general interest that was taken from the start in these international expositions even when held abroad. But of course it was at home that the greatest interest centered and where the greatest expense was incurred and the most extensive displays were made.

At the Columbia Exposition held at Chicago in 1893, the road went into the matter very elaborately. The whole matter of the preparation and maintenance of a suitable exhibit for the road was again placed in charge of Mr. Ely, who assumed personal control of it. The result was an exhibit that attracted as much if not more attention than any other at the exposition and brought to the road a wide reputation for energy and public spirit; and the possession of first class facilities.

A building was erected having a length of one hundred and forty feet and width of forty feet. Beside this was a yard containing four lines of tracks on which were placed samples of cars and locomotives, and which was spanned by a bridge containing the latest designs in signals in use upon the road.

The exhibit constituted a very complete historical display of the art of transportation whose final development was exemplified in the, then, present condition of the Pennsylvania R. R.

To the searcher after the antique there were hundreds of interesting relics, displayed in frames in the exposition building. There were photographs of points along the line of the road both preceeding its construction and during the whole of its later development. These pictures were also extended to cover the branch and subsidiary lines that have since been absorbed into the system. The main industries were represented by photographs of their buildings and premises, and to this must be added a vast collection of hundreds of objects and documents all bearing on the development of the road and each having its own part in the development; while to show in contrast the affairs of the past with those of the present there was a large collection of time tables, circulars and posters, each telling of the great speed at which journeys could be made in their day though it took six days to go from Philadelphia to Pittsburgh and six hours was the fast time between Philadelphia and Baltimore.

Then there was the old locomotive John Bull, built by Stephenson in 1831 for the Camden and Amboy R. R. and which had hauled its train to the exposition as a sort of parade preceding the show. There was the little old engine of about six tons' weight, with its train of diminutive cars and with it the, then, great engines and cars of the day. There were also many models of locomotives, cars and canal boats that had been used in the old through line to Pittsburgh, when the journey could be made with "trifling" fatigue in six days by means of the combination of rail and canal that then existed. And, even antedating this, then, rapid means of transportation, there were shown the old stage coaches and the Conestoga wagon that were the pioneers of transportation of passengers and freight between Philadelphia and the west, that guaranteed a Pittsburgh delivery in twenty days.

Then there were shown, by model, photographs or original, the whole series of vehicles that intervened and which formed the successive steps of the evolution from the primitive conveyance of the early days to the latest design of 1893, whose capacities were to those that preceded them as the ton is to the hundred weight; and showing with a distinctness that no words can convey the contrasting conditions between the old and the new.

Finally there was a group of statistical models serving to give graphic illustrations of the immensity of the traffic and materials that go to make up what is known as the Pennsylvania Railroad. To those, who had been in Egypt, possibly the most striking of these models was one showing the pyramid of Cheops, the mighty monument of the ancients, that had so often been lauded as the impossible of reproduction, and beside it another on a base of the same size, but towering to fourteen times its height, representing the bulk of the stone ballast used in the tracks of the road.

There was another illustrating the fact that the travel on the Pennsylvania was such that it amounted to the hauling of a passenger around the world in seven and three-quarter seconds, and of a ton of freight over the same equatorial circle in 63 seconds. Then it showed by working models that the coal consumption of the road was two and one-half tons of coal every fifteen seconds; that the locomotives evaporated more than a million gallons of water an hour, and that the product of an oil well supplying three hundred and seventy-five barrels a day, could just maintain the supply for the consumption of the road.

It was the greatest lesson in transportation that had ever been given to the world, and its impression on those who saw it was deep and lasting.

At the Louisiana Purchase Exposition, held at St. Louis, Missouri, in 1904, Mr. Ely made a radical departure from the character of the exhibit made at Chicago eleven years before. Instead of the historical features which had there been brought to the front, he showed by model, map and machine the great engineering feats that had been accomplished or were in process of accomplishment by the road. A separate building was not erected, as on the previous occasion, but in its place a space of ninety-four and a half feet by three hundred and thirty feet was occupied at one end of the Palace of Transportation. The minor items of improvement, each great in itself and occupying a minor place only because of its contrast with the work of the New York Terminal, were shown by maps. There were the alinement changes between Trenton and Morrisville, at Duncannon, between Lilly and Portage between Wilmore and Summerhill, and at Irwin; the track elevation at Wilmington and the stone bridges at Silver Lake, New Brunswick and Rockville; three structures of 800 feet, 1,500 feet and 3,850 feet respectively. The changes of alinement effected a shortening of the line by 8,460 feet, and an elimination of many degrees of curvature as well as an increase in the radius of those remaining.

Then there was a statistical exhibit of the condition and growth of the voluntary relief and pension departments, showing the millions of dollars that had been collected and disbursed and the part played by the railroad in the support thereof.

The exhibit of rolling stock was limited to a postal car and the De Glehn compound locomotive. The postal car was, however, really a government exhibit intended to give the public an idea of the methods employed in handling, sorting and distributing the mails.

The compound locomotive was one that had been purchased by the road for experimental purposes, and was shown as illustrative of the highest type of French locomotive construction.

But the two exhibits which overshadowed all others, and which made the greatest impression on visitors were those of the New York Terminal and the locomotive testing plant. There was a model of the great station itself, another of the East River tunnels and a full size section of the tunnel with a car in place, to which must be added a large collection of photographs and maps illustrative of the great work. It was an incentive to go and see the accomplished fact, these exhibits of models, and to describe them in full would be to tell the whole story of the great undertaking.

But even overshadowing this terminal exhibit, as an exhibit, was that of the locomotive testing plant. Years before a small plant for testing the workings of locomotives had been built at Perdue University at Lafayette, Indiana. The results obtained were of such value, that the Pennsylvania Railroad decided to build a large and improved plant for its own use in connection with its testing laboratory at Altoona. The designing of the plant was entrusted to Mr. Axel S. Vogt, the mechanical engineer and Mr. A. W. Gibbs the general superintendent of motive power who began work on the plans in August, 1903.

The plant was designed along much more liberal lines than those limiting the Purdue apparatus, and it was given a sufficient flexibility and capacity to provide for the accommodation of locomotives of widely varying types and dimensions. It was the original intention to merely erect and exhibit the plant at St. Louis, and then remove it to Altoona where it should form a part of the regular laboratory apparatus. But as its great value came to be more thoroughly realized, it was decided to put it in operation and make running tests of as many locomotives as possible during the progress of the exposition. This was done and elaborate running tests were made with eight locomotives, the results of which were published by the railroad company.

This was undoubtedly the largest and, from the scientific standpoint of locomotive designing and operation, the most important exhibit ever made by a railroad company at any international exposition.

These are the great expositions in which the Pennsylvania has had a part as an exhibitor. But it is not in the great world wide affairs alone in which it has taken an interest. Whatever has made for welfare and advancement has received its sanction and its help. And in everything that it has done along these lines Mr. Ely was in charge up to the time of his retirement. So there is a long list of minor fairs and expositions at which the road was represented, stretching from the spring of 1907 to the time of his retirement. In this list there was but one that could be regarded as of even the second magnitude, and that was the Jamestown Exposition held at Norfolk, Virginia, in the summer of 1907. Here the exhibit consisted solely of matters pertaining to the New Terminal in New York. There was a full size action of the tunnel, Models of the Long Island and Bergen tunnels, with photographs of the work and samples of the material used. It was small and taken, for the most part, from what had been shown at St. Louis two years before.

These same exhibits form part of them, have been sent to a number of places where minor expositions have been held, such as the Western Pennsylvania Exposition in

1905, the annual convention of the Engineers' Society of Pennsylvania at Harrisburg in 1909; the Alaska-Yukon-Pacific Exposition at Seattle in 1909; the Boston Exposition of 1909, where were also shown a series of photographs of all steel rolling equipment; the convention of the American Institute of Architects at Washington in 1909; the Universal City-Planning Exposition at Berlin, Germany, in 1910 the Permanent Exhibit of the New England History Teachers' Association at Boston. It has also entered the list of those exhibitions that have been founded for the purpose of showing devices that make for safety, comfort and health, and among these we find the Pennsylvania Railroad represented at expositions of Safety Devices and Industrial Hygiene at New York in 1908 where it showed the devices used and installed on its trains and in its stations for aid for the injured under the supervision of its own relief department; at the first American International Humane Conference at Washington in 1910; at the Milk Show in Philadelphia in 1911, where it showed its live stock cars and methods of handling milk shipments, and at the Land and Irrigation Exposition in New York in 1911, where it showed the work it is doing in its farmers' demonstration train and in forestration and agricultural development. Finally to this must be added the historical exhibits of its cars and locomotives and by-gone methods of transportation that were shown at Founders' Week Celebration in Philadelphia in 1908 and at the Western Pennsylvania Exposition at Pittsburgh in 1911.

The management of all this was centered in Mr. Ely's office but so quietly and systematically was it done, and so thoroughly was the personality of the individual submerged in the work of the road, that few beyond his immediate associates had or have any idea of his connection with this long string of industrial expositions. A connection that few had equalled, and which shows the alertness of the great organization with which he was connected to recognize everything that makes for the general advancement of the community. At times, as at Chicago and St. Louis, the road's exhibit stands out preeminent among its fellows and attracts universal attention and comment. At others it is in the front rank, and always of the best.

Other railroads have taken part in the great industrial expositions, but there is none that is so self-contained that it has been in a position to rival the Pennsylvania in the wherewithal to prepare a great exhibit. In which respect it stands practically alone.

Valve Gears for Three-Cylinder Engines

By W. G. Landon

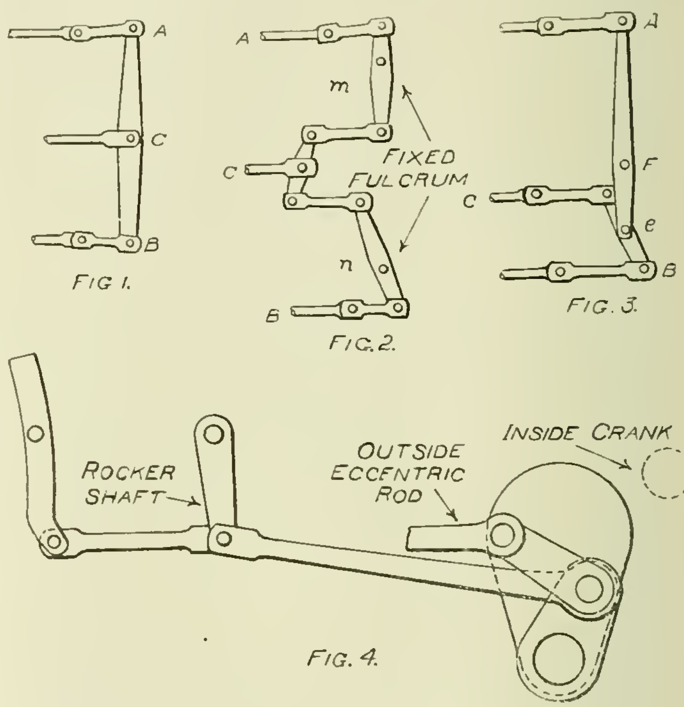
One of the first designs for operating the valves of a three-cylinder engine by the combined use of two valve gears, was patented by Joy for marine engines. His arrangement is shown in Fig. 1.

In this the two ends of a lever are attached to the extensions of the outside valve stems at *A* and *B*, and it is connected at its center to the valve stem of the third or middle cylinder. This arrangement is based upon the principle that the sequence of events in any one valve of a three-cylinder engine having its cranks set at 120° from each other, is midway between similar events of the other two valves.

This gear, however, reduces the travel of the one in the center to one-half that of the other two valves at *A* and *B*. It also requires an outside admission for the center valves if those a *A* and *B* have inside admission and vice versa. Obviously such an arrangement is not suited to locomotive practice.

Fig. 2 is a German development of the same idea as it was applied to some 4-6-0 locomotives. The two arms of the levers *m* and *n* are in the proportion of 2 to 1, and the long end of each reverses and doubles the travel of *A* and *B*. Therefore the resulting movement imparted to *C* is equal to the travel of the outside valves and correct for the same type of admission. The disadvantages of this arrangement are: The rather large inertia stresses due to the 2 to 1 ratio of the outside levers and the great number of pins required with the corresponding chance for lost motion.

Fig. 3 shows a device used on the London & North Eastern Ry. and in other places. *F* is the fixed fulcrum of a long lever, whose arms are proportioned 2 to 1.



Designs of Valve Gears for Operating Three-Cylinder Engines

The movement at (*c*) is one-half the travel of *A*. The short lever is fulcrumed on a connection to the valve stem of the valve *B* and, therefore, when (*c*) moves one-half the travel of *A*, it causes *C* to move 2x½ or a distance equal to the travel of *A*.

Fig. 4 shows the valve gear of a German 2-8-2 locomotive. As this engine has wheels of moderate diameter and is used in passenger service, either of the foregoing methods would result in rapid wear on the outside valve gears because of the inertia forces of the rather heavy levers, so that an independent gear is fitted to the center valve. The novelty of this independent application consists of using an outside eccentric crank operating through the medium of a rocker shaft, instead of an inside eccentric. All three eccentric cranks are on the axle back of the main driving axle, one being on the right hand side and two on the left. Although more expensive in first cost, such an arrangement is probably superior in the long run to the combination lever arrangements. The high boiler makes the inside gear easily accessible.

Although there are advantages in three-cylinder engines, it should be noted that the two railways (the Great Western and the Nord) running the fastest trains in Europe do not use this type. The Great Western favors the four-cylinder simple, and the Nord uses the four-cylinder compound almost exclusively.

Shop Kinks

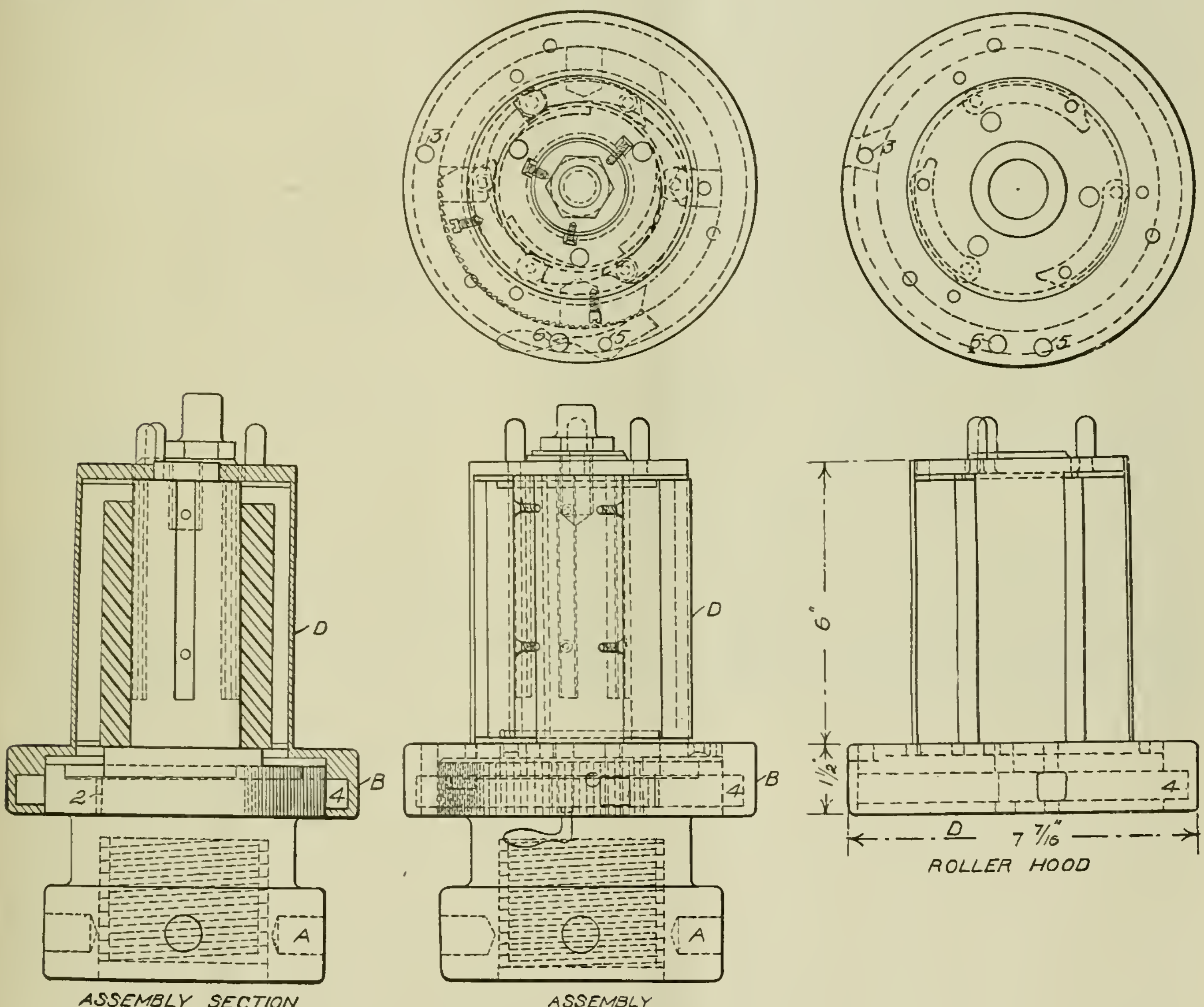
An Expanding Mandrel Developed in the Shops of the Chesapeake & Ohio Ry.

In the September issue a description was published of a universal chuck that had been developed in the shops at Richmond, Va., of the Chesapeake & Ohio Ry., and which is now being manufactured by the Commonwealth Supply Co. of the same place. Another device developed in the same shops and now manufactured by the same company is here shown. It is known as the Gary-Moss mandrel and can be used on lathes or boring mills and is especially adapted for heavy work.

Its principle of operation is the same as that of a bicycle coasting brake. That is there are rollers against which the work rests and which are forced by it against cams, that, in turn, force the rollers out against the work, so that the greater the pull of the cutting tool the more firmly is the work held.

Referring to the engravings of the assembly and details a rather close attention will be required in order to get a clear idea of the way in which the details for the application of the fundamental principle have been worked out.

First there is the base *A*, the bottom of which is shown as being internally threaded to screw upon the spindle of a lathe, and with side holes for the use of a spanner wrench in tightening and loosening. The same can be used on a boring mill by having a base, to be bolted to the table and an upwardly projecting teat threaded to fit the base of the mandrel. A collar *B* set well above the boss at the bottom of the boss at the bottom of the base has a rack *C* dovetailed into it and held in place by 1/4-in. by 3/4-in. filister head machine screws. This



Gary-Moss Expanding Mandrel

rack is made of tool steel and tempered. It has a circumferential length of 6 1/4 in. and is cut with ratchet teeth 1/16 in. deep and with a pitch of 5/32 in. As the diameter of this collar is 6 in. the rack extends through an angle of a trifle more than 120 degrees.

The upper part of the base is cylindrical 5 11/16 in. high, and 2 1/4 in. in diameter and is cut with three 3/8-in. by 3/16-in. keyways set at equal distances about the circumference. At the top is a boss 11/16 in. high and 19/64 in. in diameter.

Setting down over the upper cylindrical portion of the base and keyed to it is the chucking hub *C*. This hub is made of tool steel and is tempered. It has three cams (1) on its periphery which are essentially of the same shape as those used in the coasting brake already referred to. It will be seen, upon looking at the plan, that, when given the usual counter-clockwise movement of the spindle of a lathe or boring mill, any roller resting upon the surfaces of these cams and encountering a resistance would tend to roll towards the point of greatest diameter and thus crowd out upon any restricting surface.

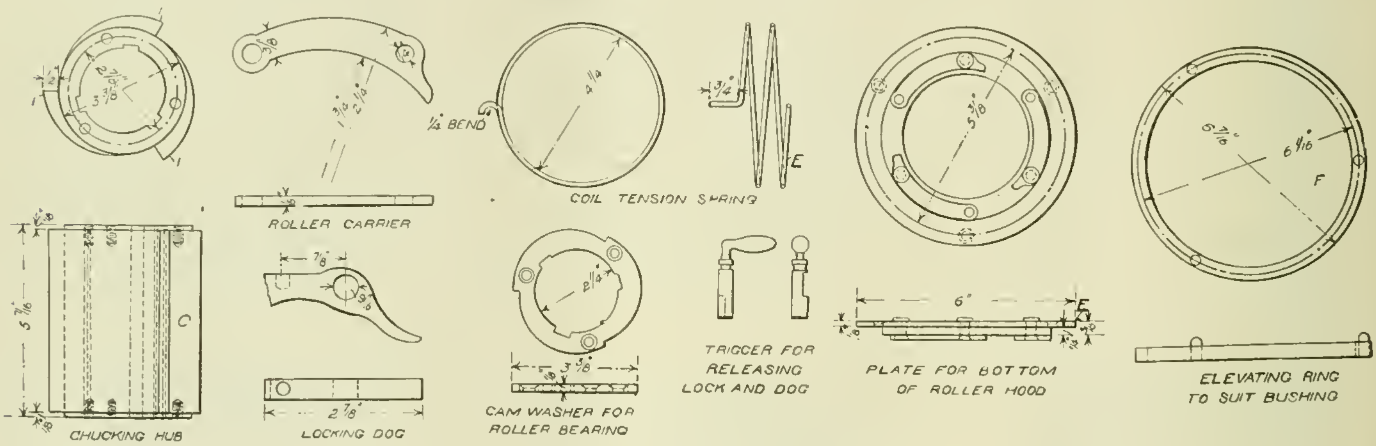
This hub is keyed in place by three spline keys each of which is held in place in a keyway of the chuck base by a ¼-in. machine screw with a countersunk head.

Over this there is set the roller hood *D* which carries in and with it the bottom plate *E* for holding the lower roller carriers, the roller carriers themselves and with the latter the three tightening rollers.

This hood is set loosely down over the chucking hub so that, as the pitch of the ratchet is 5/32 in., when one is in engagement with the tooth the other rests half way between two consecutive bearing points of the same.

These retaining pawls are set in the recess 4 of the hood and pivotted at 5. There is a hole in the flange of the hood by which they can be reached from the outside. In the hole 6 there is a releasing trigger that, when given a quarter turn, presses upon the tails of the pawls lifting the points from their engagement with the ratchet, and permitting the hood with the rollers to be turned back counter-clockwise and thus release the work.

The rollers are 5⅝ in. long and ⅝ in. in diameter, and are carried on trunnions at each end which are ¼ in. in diameter and ⅛ in. long. Of course these trunnions serve merely to hold the rollers in alinement when they are not in use, and have no load to sustain. The whole load is carried by the rollers pressing directly upon their supports, the three cams of the chucking hub.



Details of Gary-Moss Expanding Mandrel

and rests upon the upper collar of which the *B* forms a part.

The lower plate *E* for holding the roller carriers is set up from the bottom and is held in place by three ¼ in. countersunk machine screws.

At the top, the roller carriers are fastened to the cover of the hood in the same way that they are fastened to the ring at the bottom.

The hood itself is a steel casting and a mere shell 3/32 in. thick with a cup shaped flange or boss at the bottom, and openings at the side for the rollers. This boss is bored out with a recess at 4 both for the purpose of lightening it and for receiving the locking dogs or retaining pawls that serve to hold the rollers out against the work and prevent slipping when they are once in place.

The roller carriers are held in place by shoulder screws having a round flat head and are loosely riveted in place.

This whole combination of the roller hood with its attachments would be free to rotate about the base and the chucking hub, were it not held by a light coil spring *E* made of ⅛ in. wire. The long stem of this spring is set down in the hole 2 of the base where it is anchored, while the bend, at the other end is caught about a pin in the hole 3, of the roller hood, a hole being cut in the side of the boss to give access to it. This spring is put into place under tension and tends to rotate the hood counter clockwise and thus carry the rollers down the incline of the cams and so loosen their grip on the work.

It is prevented from doing this, however, when the mandrel is at work by the retaining pawls which engage in the teeth of the rack. There are two of these pawls pivoted on the same center, and they vary by 5/64 in. in the distance from that center to their engaging points

Likewise the only stress put upon the roller hood falls upon the lower portion through the 5/16 in. pins on which the retaining pawls are pivoted.

At the upper end the roller hood is held down in place by a ⅝ in. tap bolt screwed into the top of the chuck base and with its nut bearing on it, and leaving the hood free to turn beneath it, and preventing it from lifting.

The manipulation of work on and off from this mandrel is very simple.

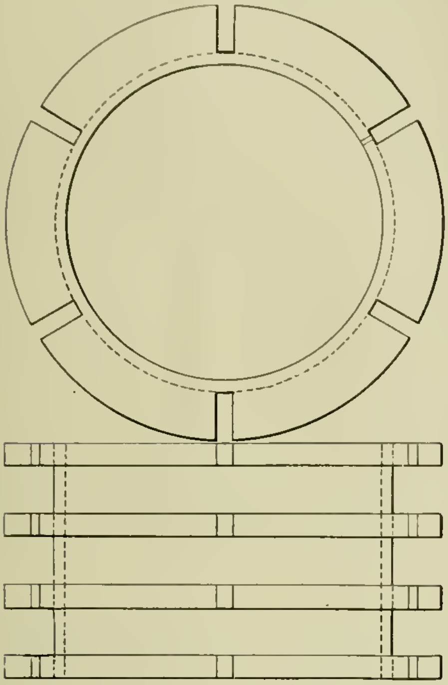
The retaining pawls are first drawn back and the hood turned back so as to run the rollers down the incline of the cams. The pawls are then released and allowed to come into engagement with the ratchet. The work is then dropped down over the hood and rollers and the whole turned by hand until the rollers grip and it can be moved no further. The pawls are thus drawn over the ratchet and, by engaging in it prevent a return movement of the hood and a corresponding release of the rollers.

When the cut is started if this preliminary tightening is not sufficient to hold the work, the cams are forced back beneath the rollers which are thus crowded out more forcibly against the work, and as, in this forward movement over the cams, they are followed by the retaining pawls, they are held there and this, with any succeeding tightening that may occur, is held against slipping.

When the work is done a quarter turn of the trigger draws the pawls away from the ratchet and the work with the hood can be turned back and the former released. It is then free to be lifted off and a new piece put in place. The time required for this is measured in seconds. There is no slipping after the work has once been gripped and no binding when it is desired to remove it from the mandrel.

It will be seen that the extreme variations in diameter that can be held by the mandrel is dependent upon the throw of the cams, and that the extreme movement of the rollers over these is limited to a diameter of 1 in. as they cannot be moved to the edge or heel of the cam the actual diametrical limitations of the work is about ¾ in.

When work of a larger diameter is to be held, a filling ring like that shown for large brasses is used. This has an inside diameter of 5 in. and an outside to suit that of the brass to be held. It is formed of a series of rings ⅜ in. thick and ¾ in. apart made integral with a central shell 3/16 in. thick. The rings are divided into six segments by slots ¼ in. wide extending from the circumference down to the shell, and the latter is itself split in one place beneath one of these slots, so that it becomes a split ring capable of considerable enlargement under the pressure of the rollers.



FILLING RING FOR LARGE BRASSES

The work is slipped down over this ring as the latter rests on the mandrel. It is then fastened as before, the rollers forcing the circumference of the split ring out against the work.

In order to raise the work slightly above the surface of the boss at the lower end of the hood an elevating ring as shown at *F* may be used. This is a plain flat ring of a thickness suited to the work to be done and fitted with three round ended pins upon which the work rests on a three-point support. This ring slips down over the rollers without touching them, and rests on the collar or boss forming the bottom of the hood.

Because of its convenience and the economy effected in the production of work, the mandrel has been patented and is now being manufactured.

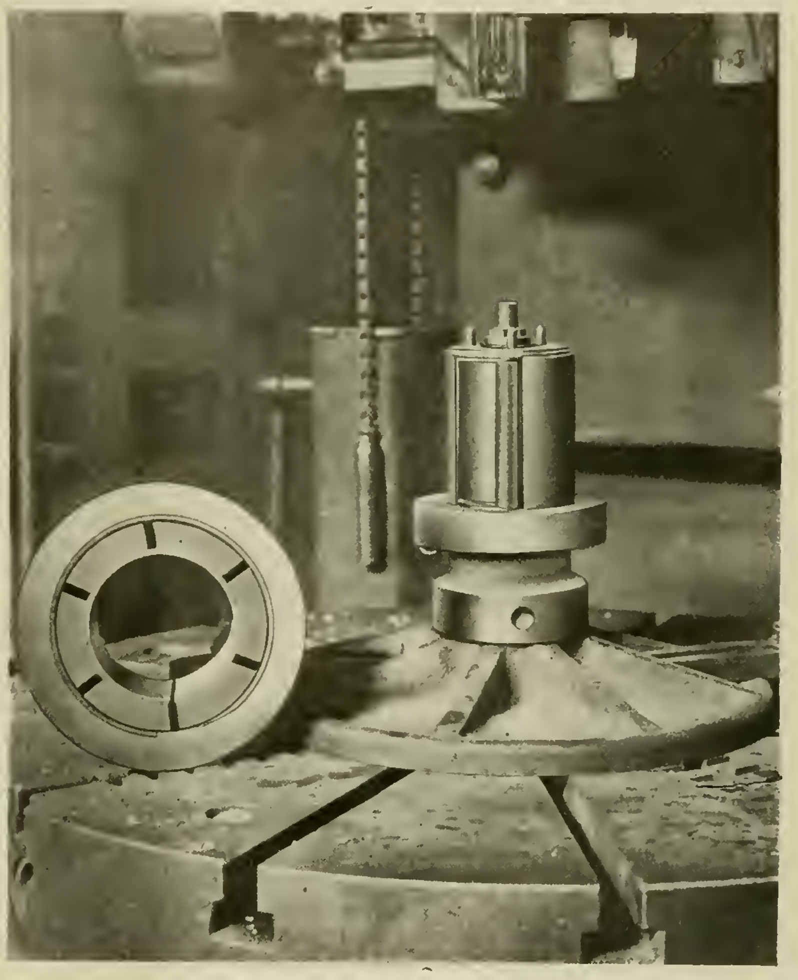
Centennial of the Baltimore & Ohio

Pursuant to a recent act of the Legislature of Maryland, Governor Albert C. Ritchie has appointed a commission looking toward the celebration of the hundredth anniversary of the granting of the charter of the Baltimore & Ohio R. R. Co., consisting of George Weems Williams, John W. Garrett, Jacob Epstein, Alexander Brown, Van Lear Black, Holmes D. Baker, Oliver H. Bruce, Jr.

The Landis Reverse Taper Die Head

The Landis Machine Company have placed upon the market a die head for cutting tapered threads on crown bolts from the big end to the small end. This head is known as the Landis Reverse Taper Die Head.

When cutting tapered threads on crown bolts, the usual practice is, of course, to thread from the small end to the large end. This usually causes the nicking of the body of the bolt, which makes the bolt unfit for service, or at least creates a tendency for the bolt to break at the place where it is nicked during the threading operation. The Landis reverse taper die head was designed to overcome this condition, and inasmuch as it cuts the tapered thread from the big end to the small end, there is absolutely no danger at all of nicking the body of the bolt.



Gary-Moss Mandrel as Applied to Boring Mill Showing Mandrel in Position; Also Large Size Bushing with Filling Ring Applied.

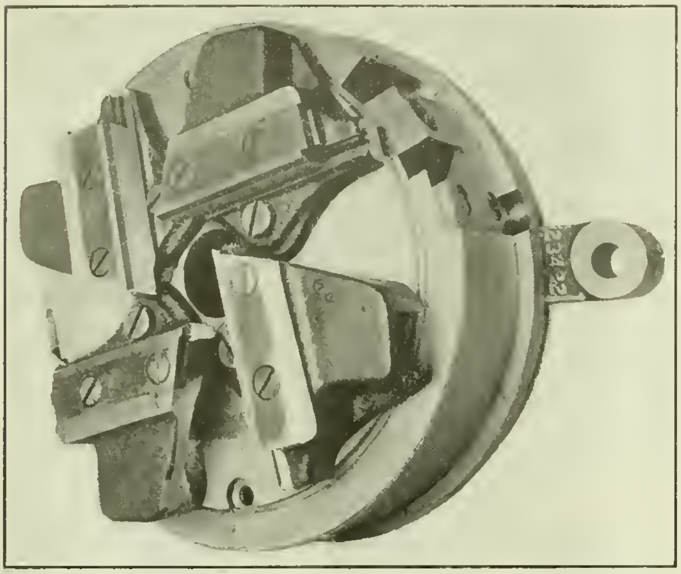
Another important feature is that the square on the end of the crown bolt does not have to be true with the body, as with the reverse taper die head the bolt is gripped on the body and not on the square for the threading operation.

This die head is furnished in the 1½ in. size only. It is 11⅞ in. in diameter and is 7-5/16 in. in length. The maximum diameter of bolt which can be threaded is 1⅞ in., while the maximum taper of thread is 2 in. per foot.

This head can be applied to any Landis threading machine having a capacity of 1½ in. or more. The machine must be equipped with leadscrew attachment to insure a thread of perfect form and correct lead. A special carriage front or trip rod brackets will be required to accommodate the two trip rods which are supplied with the head.

The die head is operated by two trip rods attached to the carriage front of the machine. The trip rods are fitted with adjustable nuts which engage the lugs of the yoke ring. The lugs are located diametrically opposite each other. The adjustable nuts are placed in contact with the lugs on the yoke ring when the work is about to enter the die head.

As the work advances, the yoke ring is pushed back taking with it the operating ring to which the cam shoes are attached. The cams are designed so that, as the cam



The Landis Reverse Taper Die Head

shoes slide over the cams, the die head is closed gradually to correspond to the taper of the thread. A set of cams is required for each taper of thread being cut.

The travel of the cam shoes must equal the length of the thread. The die head opens when the crest of the cam shoe passes the crest of the cam. Stop screws are provided to limit the opening of the head. The die head is automatically brought to the threading position as the carriage is withdrawn.

Snap Shots By the Wanderer

It is not uncommon when there is a convention or gathering of any class of railroad men, especially if the gathering happens to be a departmental one, for the official in control of that department to read the men a lecture setting forth his ideas as to the ideal to be followed and the desired qualifications of the employes before him.

The superintendents are quite given to telling the station agents as to how they should conduct themselves to the public and many is the preachment that has been sent out on that subject.

It is under the inspiration of these addresses that I am led to write to a class who are more accustomed to write than to be written to, and more accustomed to talk than to listen, and tell them what sort of men I think they ought to be. Not that it necessarily follows that it is the sort of men that they really ought to be. My real audience to whom I am addressing myself, then, is composed of the publicity men, though of course all readers of Railway & Locomotive Engineering are welcome to read and profit, if there is any profit to be had.

Of course in this, as in every other walk of life, you should be what is known as a courteous gentleman, and be able to meet all sorts and conditions of men on a footing that places them at their ease But it is in your attainments and qualifications that I am particularly interested, because I am thrown more or less in contact with your products from day to day.

Of all of your attainments I should place the ability to write good, clear, smooth and forceful English in the front rank. There is much composition in these days that is so slipshod that it is close of kin to vulgarity and ignorance, in which the daily press is showing a notable lead, that the publicity man has special need to be careful lest he fall into habits which it would be well to avoid. Carefully constructed phrasing with carefully chosen words should be your first care. Not florid but elegant.

To use such language implies the necessity for education and culture, both of which you should have.

But to use it properly and easily necessitates that you should be familiar with your subject. Your training should have been such as to make you familiar with the details of the product which you are called upon to exploit. Remember that you are something different from an advertising agent or advertisement writer. These make assertions and claims, calling attention to their wares, which the careful buyer requires to be explained and substantiated. It is your duty to explain the merits and details of the product which you can hardly do unless you are familiar with it.

The engineer who buys a lathe or any other machine tool wants to know not only what it will do but how it does it. For he will be called upon not only to justify his choice in the purchasing of your tool, but to work it efficiently and economically, and make repairs when it becomes worn. And his initial information on the subject must come from you.

If it has any peculiarity of design or construction, you should be able to tell him, of your own knowledge, as to what they are and the especial advantages which they possess. And you should be able to tell him not only by word of mouth, but to write it out for him so that he may read it a thousand miles away and get a clear idea of what you have written about, by simple reference to your text and illustrating and without seeing the actual object.

To the extent of being able to do this, you should be a trained engineer as well as a trained writer. You will then understand what it is that the engineer wants to know, and be able to tell him.

There is no fixed rule to be followed in your descriptions for each must be a law unto itself.

And you must be guided by the general character and attainments of those whom you address. Usually it is safe to assume that your readers know little or nothing about the particular thing you are writing about, but that they are quite familiar with the generalities of the class to which it belongs. If you are describing a locomotive, for example, you need not explain the peculiar or general features of say a Pacific engine, but don't content yourself with a mere list of the dimensions and special appliances. Not but that these are interesting and of value, but there is no new design of anything, be it locomotive, car, lathe, planer or screw machine, but has some peculiarity that is worthy of a description in detail. And such a description will not only increase the value of your screed but will serve to attract the attention of the reader and possible purchaser to the article that you are exploiting.

Then as a final requirement, you must be interested in your work and your product. It is your province to be interesting to those whom you wish to interest. There are two things of which you may be very sure: the interested man is almost always interesting and the uninterested man is usually a bore.

Of course all this is written with the understanding that you will be careful and painstaking in your work, and remember that any piece of writing can be improved by reasoning. "Things seen by candlelight do not always look the same by day." A good surface plate requires almost as many years of seasoning as it does hours of work to finish it. So write your descriptions, and let them stand for a few days before sending them to the printer; and, if possible, turn them over to someone, who is not an expert on your product, to read. If the lay mind can understand your technical work you may consider it safe for distribution. If it cannot then, you had best alter until it can. The great danger in technical writing, or in any writing for that matter, is that the writer being thoroughly familiar with and saturated in his subject, so to speak, is apt to express himself in a way that, while perfectly clear and lucid to himself knowing what he means, may convey a wrong or indistinct impression to a reader who is either unfamiliar with the matter discussed or approaches it from a different point of view.

I am led to write this because many of you, to be frank, do not seem to realize what we laymen would like to know, and fail to satisfy our curiosity. You will publish an illustration for example and say: "The construction is clearly shown by the illustration, "forgetting that most of us are intellectually lazy. We glance at the illustration and if that glance does not enable us to absorb the whole thing we let it go. It is very true that the construction may be clearly shown, but it may also require careful study in order to decipher its intricacies. Here is where your descriptive writing is put to the test. It is for you to analyze the construction, tear it to pieces and so handle it that he who runs may read and understand. Many a fine illustration has gone to waste because of the insufficiency of the explanatory text.

And now, at the risk of being told to practice what I preach, I am going to advise you to avoid prolixity. And summing up the specifications that you should fill, I would say that the whole may be covered by the two generalizations that, from the standpoint of an outside observer who is not and never has been a publicity agent or manager, you should be a master of the English language and a master of the subject about which you are writing, and the combination of these two will make you a master of the art of technical exposition.

Westinghouse Receives $1,000,000 Order for Staten Island Electrification

The Westinghouse Electric & Mfg. Co. announces the receipt of orders totalling approximately one million dollars for apparatus to be used in connection with the ten-million-dollar improvements which the Baltimore & Ohio Railroad is carrying out on Staten Island in electrifying the Tottenville and South Beach branches of its subsidiary, the Staten Island Rapid Transit Co.

The Westinghouse contracts cover five automatic substations with supervisory control for the Staten Island Rapid Transit Co., and high-voltage equipment for the Staten Island Edison Corporation, which will supply the power for operating the railway.

The automatic, supervisory-controlled substations, which will receive high-voltage current from the power house and transform it into low-voltage current for the railway, represent one of the most modern developments of electrical engineering, and are probably the most nearly human of mechanism ever devised.

Four of these stations will have no attendants whatever, and the fifth will be the central control station for the whole system. All of the processes of a normal character, such as increasing or decreasing the power supply in response to the demands of the railway, will be carried out automatically by the stations. Machinery will start up and shut down, switches will open and close, and other operations, sometimes of the greatest complexity, will take place without human intervention. Inasmuch as this machinery can act several times more rapidly than can the most experienced operator, and cannot make errors in connections or sequences, it provides maximum reliability of operation. Should anything go wrong, everything is instantly shut down.

In addition, each station will be under the direct and complete control of the power load dispatcher located at the central control station. This is the purpose of the supervisory control system. By means of this system the dispatcher can ask any station for information in regard to any detail of operating conditions, such as the load on a machine, the position of a certain switch, or the temperature of any one of the bearings. The information desired is promptly given him automatically by the station questioned, and he can then, by pressing the proper button, make any change at the station that circumstances may require.

Unit Costs of Operation Reduced This Year

The reduced costs of railroad operation this year as compared with last year are seen in a report just issued by the Bureau of Statistics of the Interstate Commerce Commission. The figures are compiled from 161 reports from 176 steam railroads, and they deal with freight and passenger train service unit costs.

The costs per freight train-mile in June of this year compared with June a year ago were as follows:

	1924	1923
Locomotive repairs	$0.416	$0.519
Train enginemen	.239	.256
Fuel for train locomotives	.403	.466
Enginehouse expenses	.092	.094
Trainmen	.285	.292
Other locomotive and train supplies	.110	.106
Total selected accounts	$1.545	$1.733

The costs per passenger train-mile in June of this year compared with June of last year were as follows:

	1924	1923
Locomotive repairs	$0.243	$0.287
Train enginemen	.130	.128
Fuel for train locomotives	.181	.208
Enginehouse expenses	.059	.061
Trainmen	.147	.141
Other locomotive and train supplies	.089	.091
Total selected accounts	$0.849	$0.916

International Railway Congress at London

The next congress of the International Railway Congress Association will be held in London from June 22 to July 6, 1925. Besides the regular business, the congress will make a number of excursions to places of railway interest in Great Britain—among them the Swindon works of the Great Western Railway, Darlington (where the centennial of British railways will be celebrated), Windsor, Canterbury, Edinburgh, Glasgow and the great Clyde industrial district. The chairman of the arrangements committee is Sir Evelyn Cecil, G. B. E., director of the Southern Railway, 2, Cadogan Square, London, S. W. 1.

Notes on Domestic Railroads

Locomotives

The Chesapeake & Ohio Railway is reported to be inquiring for 25 locomotives.

The Illinois Central Railroad has ordered 25 heavy Mountain type locomotives from the Lima Locomotive Works.

The San Antonio & Arkansas Pass Railway has ordered 5 American type locomotives from the Baldwin Locomotive Works.

The Missouri Pacifice Railroad has placed orders for 35 locomotives with the American Locomotive Company. The order includes 10 Pacific type and 25 Mikados and 15 eight-wheel switchers with the Baldwin Locomotive Works.

The Jefferson Southwestern Railroad has ordered one Consolidation type locomotive from the American Locomotive Company.

The Detroit Terminal Company is inquiring for 2 switch engines.

The Jodhpur State Railway of India has placed an order with the Baldwin Locomotive Works for 5 Mikado type locomotives.

The Chesapeake & Ohio Railway has awarded a contract to the American Locomotive Company covering repairs to 25 Mallet locomotives. The works will be done at the Dunkirk plant.

The Angelina County Lumber Company has ordered one Mikado type locomotive from the Baldwin Locomotive Works.

The Sorocabana Railway of Brazil has placed orders with the American Locomotive Company for 9 Mikado type locomotives.

The Gray Lumber Company, Waverly, Va., is inquiring for a 40-ton Mogul type locomotive, narrow gauge.

The Southern Railway is inquiring for 25 Mikado type locomotives, 15 Pacifice type and 10, 8-wheel switching type locomotives.

The Detroit Toledo & Ironton Railroad has ordered 6, 8-wheel switching locomotives from the Lima Locomotive Works.

The New York Central Railroad is inquiring for 10 Pacific type locomotives.

The Owen Oregon Lumber Company has ordered one Mikado type locomotive from the Baldwin Locomotive Works.

The Southern Railway has placed an order with the American Locomotive Company calling for the delivery of 50 engines. The value of this order is estimated at between $2,500,000 and $3,000,000.

Freight Cars

The Reading Company has placed an order for 1,000 hopper cars with the Bethlehem Steel Company.

The Gulf Coast Lines are inquiring for 1,250 freight cars as follows: 500, 40-ton box cars; 500, 40-ton automobile cars and 250, 40-ton gondola cars.

The Gulf Coast Lines has ordered 500 box cars from the American Car & Foundry Company, 500 automobile box cars from the Pullman Company and 250 gondola cars from the Mount Vernon Car Company.

The National Railways of Mexico has placed an order for 200 standard gauge tank cars and 50 narrow gauge tank cars with the General American Tank Car Company.

The Southern Railway has ordered 2,000 box cars and 250 flat cars from the American Car & Foundry Company; 1,000 box cars from the Mount Vernon Car Company and 400 stock cars from the Tennessee Coal & Iron Railroad Company.

R. C. Wayne Supply Company is inquiring for 4 flat cars, 20 ft. long for the U. S. government.

The Ulen Contracting Company, New York City has ordered 5 special tank cars of 5,000 gal. capacity from the Magor Car Corporation.

The Missouri Pacific Railroad is inquiring for 50 caboose cars.

The Manila Railroad has ordered 30-ton flat cars from the Koppel Car & Equipment Co., Koppel, Pa.

The General Petroleum Corp., Los Angeles, Calif., has placed an order with the Pennsylvania Car Company for 10 tank cars, 10,000 gal. capacity.

The Chicago Indianapolis & Louisville Railroad has placed an order with the Pullman Company for 250 underframes.

The St. Louis San Francisco Railway is inquiring for 400 underframes.

The Great Northern Railway is inquiring for 250 ore cars of 75 tons' capacity, and for 600, 40 tons and 100, 50 tons automobile cars.

The Chicago Indianapolis & Louisville Railroad is inquiring for 500 box cars.

The Southern Railway is inquiring for 2,500 box cars of 40 tons' capacity, 250 stock cars of 40 tons' capacity, and 250 flat cars of 50 tons' capacity.

The New York Central Railroad is inquiring for 200 stock cars and 200 flat cars of 40 tons' capacity.

The Texas & Pacific Railway has placed orders for 2,000 freight cars as follows: 1,000, 40-ton double sheathed automobile-box cars with the American Car & Foundry Company, 1,000, 40-ton single-sheathed automobile box cars with the Pullman Company.

The Union Refrigerator Transit Company has ordered 200 underframes from the American Car & Foundry Company.

The Central Vermont Railway has given an order for the repair of 300 box cars to the American Car & Foundry Company.

The Missouri Pacific Railroad has ordered 75 caboose cars from the American Car & Foundry Company.

The National Railways of Mexico has ordered 200 standard tank cars of 10,000 gal. capacity and 50 narrow tank cars from the General American Tank Car Corporation.

The Pennsylvania Railroad has ordered 10,000 all steel box cars as follows; 2,500 Pressed Steel Car Company, 2,500 to the American Car & Foundry Company, 2,500 to the Standard Steel Car Company, 2,500 to the Bethlehem Shipbuilding Company.

The Reading Company is inquiring for 1,000 box cars and 1,000 gondola cars.

The Baltimore & Ohio Railroad is reported to be inquiring for 8,000 freight cars.

The Hudson Coal Company, Scranton, Pa., has ordered 30 ore cars from the American Car & Foundry Company.

H. J. Heinz Company, Pittsburgh Pa., is inquiring for ten flat cars.

The Union Carbide Company has ordered 6 special tank cars of 40 tons' capacity from the General American Tank Car Corporation.

The Chicago Burlington & Quincy Railroad is reported to be inquiring for 3,000 freight cars.

The United States Rubber Company has placed an order for ten tank cars with the American Car & Foundry Company.

The Atlantic Coast Line is reported to be inquiring for 3,000 freight cars.

The Pere Marquette Railway has ordered 12 caboose underframes from the Pressed Steel Car Company.

The Reading Company has ordered 500 box cars of 50 tons' capacity from the American Car & Foundry Company, 500 box cars of 50 tons' capacity from the Standard Steel Car Company, 500 gondola cars of 70 tons' capacity from the Pressed Steel Car Company and 500 gondola cars of 70 tons' capacity from the Bethlehem Steel Corporation.

Passenger Cars

The Erie Railroad has ordered 8 combination passenger and baggage gasoline motor cars from the J. G. Brill Company.

The New York, New Haven & Hartford Railway has ordered 10 motor cars from the Sykes Company for use on its branch lines.

The Lehigh Valley Railroad is inquiring for 2 dining cars.

The Northern Pacific Railway has placed an order with the Oneida Mfg. Company for the installation of Oneida power units on a combination car.

The Texas & Pacific Railway is inquiring for 10 baggage-express cars and 3 baggage-mail cars.

The Illinois Central Railroad has issued an inquiry covering 278 passenger cars, as follows: 30 coaches, 8 compartment coaches, 6 chair, 9 baggage, 10 baggage-mail, 85 suburban trailers, and 130 suburban motor cars.

The Chicago Burlington & Quincy Railroad it is reported will shortly issue inquiries covering 25 baggage cars.

The Missouri Pacific Railroad is inquiring for 2 diners and 2 parlor cars.

The New York, New Haven & Hartford has ordered from the J. G. Brill Company one gasoline-electric car.

The Illinois Central Railroad has placed an order with the American Car & Foundry Company for 200 express refrigerator cars.

The Atchison Topeka & Santa Fe Railway expect to come into the market soon for some passenger equipment.

The Missouri-Kansas-Texas Railroad has ordered one combination passenger and baggage gasoline motor car and one passenger trailer car from the J. G. Brill Company.

The Southern Railway is inquiring for 25 steel passenger coaches, 10 combination baggage and express cars and 3 dining cars.

The Pnxiana Coal & Coke Company has ordered one combination passenger and baggage gasoline motor car from the J. B. Brill Company.

The Baldwin Locomotive Works is inquiring for 3 passenger car bodies, with rear trucks, one to be narrow gauge and the other 2 to be standard gauge.

The Louisiana & Northwestern Railroad has placed an order with the J. G. Brill Co., for one combination passenger and baggage gasoline car.

Building and Structures

The Southern Railway plans the construction of a 12-stall concrete roundhouse at Asheville, N. C.

The Chicago Rock Island & Pacific Railway has awarded a contract covering the construction of a frame enginehouse and repair shop at 47th street, Chicago, Ill.

The Western Maryland Railway has awarded a contract for the rebuilding of an enginehouse at Bowest, Pa., which was damaged by fire; estimated to cost $35,000.

The Louisville & Nashville Railroad and the Atlantic Coast Line Railway plan expenditures of $1,500,000 on the shops of the Carolina Clinchfield & Ohio Railway at Erwin, Tenn.

The Chesapeake & Ohio Railway is reported to be planning an expenditure of $8,000,000 in improvements in and about Richmond, Va., including the construction of shops at Fort Lee.

The Atchison Topeka & Santa Fe Railway plans the construction of shop buildings at Phoenix, Ariz. to cost approximately $1,000,000.

The Cincinnati Georgetown & Portsmouth Railroad has placed a contract for the construction of a car repair shop at Cincinnati, Ohio.

The Canadian National Railways have placed a contract covering the construction of a six-stall roundhouse at Nutana, Sask., Canada.

The Sioux City Terminal Railway has awarded a contract covering an enginehouse and a machine shop, 100 by 150 ft., fireproof construction.

The Cincinnati Indianapolis & Western Railroad has purchased the car and locomotive repair shops at Hammond, Jeffers & Brazil, Indiana and will operate the plant as a unit of the railway shops.

The New York Central Railroad has awarded a contract covering the construction of a one- story car repair shop at Hammond, Ind., to be 90 by 130 ft., to cost approximately $45,000.

The Western Maryland Railway has placed a contract covering the construction of a locomotive repair shop and engine house at Dunbar, Pa.

Items of Personal Interest

H. P. Allstrand, master mechanic of the Chicago & Northwestern Railroad, with headquarters at Boone, Iowa, has been promoted to general supervisor of efficiency, with headquarters at Chicago, Ill.

Frank J. Regan, has been appointed fuel supervisor of the Northern Pacific Railway, with headquarters at Duluth, Minn, succeeding **Mr. Montgomery**, deceased.

W. H. Halsey, master mechanic, with headquarters at Belle Plaine, Iowa, has been transferred to Boone, Iowa, succeeding **Mr. Allstrand**, who has been promoted.

L. P. Ligon, inspector of shops and equipment of the Norfolk & Western Railway, has retired recently after having been in the service of the company for about 50 years.

J. F. Franey has been appointed general foreman of the Western shops of Denver & Rio Grande Western Railroad, with headquarters at Denver, Colo. Mr. Franey was formerly machine shop foreman on the Rock Island Lines, with headquarters at Horton, Kan.

D. M. Raymond, car foreman of the Union Pacific Railroad, with headquarters at Green River, Wyo., has been promoted to general car foreman, with headquarters at Council Bluffs, Iowa.

F. A. Banning has been appointed shop foreman of the Rock Island Lines shops at Horton, Kans., succeeding **J. F. Franey**, who resigned to become general foreman of the western shops of Denver & Rio Grande Western Railroad.

E. Gelzer, mechanical engineer of the Chicago Great Western Railroad with headquarters at Oelwein, Iowa, has resigned.

J. F. Hunt, Jr., gang foreman of the Pennsylvania Railroad with headquarters at Rose Lake, Ill., has been appointed motive power inspector of the shops at Meadows, New Jersey.

D. H. Jenness has been appointed road foreman of engine on the Pennsylvania Railroad, with headquarters at Logansport, Ind., succeeding **M. E. McDonald**, who has been transferred to Chicago.

W. C. Beck has been appointed assistant superintendent of the Canadian Pacific Railway. Mr. Beck was formerly chief clerk to the vice-president.

Harry Loughlin, enginehouse foreman of the Pennsylvania Railroad, with headquarters at Elmira, New York, has been transferred to Sharpsburg, Pa.

Otto Burgert, general foreman of the Pennsylvania Railroad, with headquarters at Rose Lake, Ill., has been appointed enginehouse foreman, with headquarters at Effingham, Ill. The position of general foreman at Rose Lake, Ill., has been abolished.

Supply Trade Notes

A. J. Pizzini, president of the **Railway Improvement Company**, New York City, has also been elected president of the **Waugh Equipment Company**. Mr. Waugh becomes chairman of the board.

The **Davis Brake Beam Company** has appointed **Hughes & Craul**, Peoples Gas Building, Chicago, Ill., as their northwestern representatives.

E. R. Mason, Grand Central Terminal, New York City, has been appointed district sales manager of all the New England states, also in New York, New Jersey, Pennsylvania and Delaware for the **Fairmont Railway Motors Company, Inc.**, Fairmont, Minn.

H. T. Heath has been appointed western department manager of the **Hegeman-Castle Corporation**, of Chicago, Ill., owned and controlled by the **National Railway Appliance Company**, New York City.

Clayton R. Burt, president and general manager of the **Austin Machinery Corporation**, Chicago, Ill., has been elected general manager of the **Pratt & Whitney Company, Hartford**, Conn., to succeed B. H. Blood, resigned.

H. C. Storr, of the general sales department of **S. F. Bowser & Company**, Ft. Wayne, Ind., has been promoted to assistant sales manager, with the same headquarters.

H. P. Anderson, formerly superintendent of motive power of the Missouri-Kansas-Texas Railway, has been made mechanical engineer of the **Standard Stoker Co., Inc.**, Grand Central Terminal, New York City. Mr. Anderson's headquarters will be at Erie, Pa.

R. K. LeBlond Machine Tool Company, Cincinnati, Ohio, plan to erect a branch factory at Long Island City, N. Y., and has purchased land for the purpose.

P. R. Drenning has been retained by the **Rogatchoff Company**, of Baltimore, Md., as consulting engineer and as sales manager in the southern territory.

The **Electric Welding Supply Sales Co.**, 45 L Street, Boston, Mass., has been incorporated and has taken over the business of the firm of the same name.

F. J. DeLima has been made manager of electric welding department of the Montreal office of the **Gibbs Instrument Company**, Bay City, Mich.

J. Beaumont, vice-president and sales manager of the **Regan Safety Device Company**, has transferred his office from Chicago to New York City.

John Burnham & Company have secured the controlling interest in the **Ryan Car Company**, Chicago, Ill.

F. H. Smith has been made manager of the Cleveland office of the **Southwark Foundry & Machine Company**, Philadelphia, succeeding **H. D. Andress**.

B. N. Broido has been appointed chief engineer of the industrial department of the **Superheater Company**, of New York and Chicago.

The **Linde Air Products Co.**, New York, N. Y., has secured a site at Roanoke, Va., and it is reported plans the construction of an oxygen plant there.

The **Mt. Vernon Car & Mfg. Co.**, Mt. Vernon, Ill., is taking bids covering the erection of a new foundry estimated to cost $300,000, to be one-story, 240 by 350 of brick and steel.

Gordon H. McCrae, manager of the London office of the **Independent Pneumatic Tool Company**, has been elected a vice-president of the company.

The **Falls Hollow Staybolt Company**, Guyahoga Falls, Ohio, has appointed the **Tabson Company** as its special representative in Illinois, with headquarters in the Railway Exchange Bldg., Chicago, Ill.

T. H. Goodnow, formerly superintendent of car service of the Chicago & Northwestern Railway and later vice-president of the **Ryan Car Company**, has resigned the position to become vice-president of the **Camel Company**, with headquarters at 332 South Michigan Avenue, Chicago, Ill.

Henry T. Stetson has been elected a director of the **Safety Car Heating & Lighting Company**.

The **Detroit Machine Tool Company**, manufacturers of centerless grinding machines, has been consolidated with the **Norton Company**, Worcester, Mass.

A. C. Irwin has been appointed manager of the railway bureau of the **Portland Cement Associates**, with headquarters at 111 West Washington Street, Chicago, Ill.

The **Air Reduction Sales Company** has completed new plants at Birmingham, Ala., Harrisburg, Pa., and Seattle, Wash. It has also added a new unit at the plant at Chicago, and has doubled the capacity of the plant at Baltimore. This expansion program, which is now well under way, will be completed when the oxygen plant at Lima, Ohio, is finished and three other plants are remodeled.

This company has placed ten plants in operation since 1922 and now has forty-five plants in all.

The Central Iron & Steel Company has appointed the **Cameron & Barkley Company, S. C.**, their representative in the Charleston district.

C. Bermingham has been elected a director of the **Canadian Locomotive Company, Ltd.**, succeeding **W. Y. Soper**, deceased.

The Federal Signal Company, Albany, New York, has been absorbed by the **General Railway Signal Company**.

Obituary

William Garstang, who for many years was a prominent member of the American Railway Master Mechanics' Association and of the Master Car Builders' Association, died at his home in Indianapolis on September 12. At the time of his death and since his retirement from railway service he had acted as the Indianapolis representative of the Gould Coupler Company. Previous to that and up to December, 1913, he had been the general master car builder of the Cleveland, Cincinnati, Chicago & St. Louis and the Peoria & Eastern Railways.

Before his retirement he had been in railroad service for 52 years and been associated with the two great railroad mechanical associations for 35 years and was president of the Master Mechanics' Association in 1894-95.

Among his activities in the Master Car Builders' Association, he served as chairman of the committee on standard wheels for a number of years and was also a member of the committees on the standard car axle, and journal box, brass and wedge.

He was general master car builder of the Cleveland, Cincinnati, Chicago & St. Louis Railway at the time the Beechwood shops of the road were built and was responsible for their designing and erection.

Mr. Garstang was born in England on Feberuary 28, 1851, and came to this country at an early age. When he was only eleven he served as a water carrier for the track laying gang that was building the road from Fort Erie to Niagara, and two years later entered the railways shops of the Cleveland & Erie Railroad at Cleveland as a machinist's apprentice, where he remained for six years.

While at work as an apprentice he went to night school and studied mathematics and mechanical drawing. Then for eleven years he worked as a machinist and general foreman for the Atlantic & Great Western and the New York, Pennsylvania & Ohio Railroads. This was followed by three years as general foreman of the Cleveland & Pittsburgh division of the Pennsylvania, and five years as master mechanic of what was afterwards the Cleveland, Cincinnati, Chicago & St. Louis Railway, of which he became superintendent of motive power in 1893, having, in the meantime, been superintendent of motive power of the Chesapeake & Ohio for five years, commencing in 1888.

In February, 1913, after holding the position of superintendent of motive power on the one road for 20 years, he was relieved of a portion of his duties, retaining the title of general master car builder, and then 10 months later, in December, 1913, he definitely retired.

By those who had the good fortune to be associated with him, Mr. Garstang will be remembered for a few outstanding characteristics that make for success and popularity. He was, first of all, interested in every progressive movement that made for the improvement of railroad service, both from the standpoint of the public and of the official. His interest in all of the details of railroad work was intense, and he was keenly alive to every possible improvement. Not that he was swept off his feet by every suggestion, but he weighed what was presented to him with great care and caution and if it appeared well to his practical common sense and theoretical viewpoint he would adopt it. Then there was his genial and pleasant disposition. He was among the most approachable of men; ready to give of his best to whoever came to him for for advice or assistance, and withal so honest in the opinions that he gave, that his criticism was always well worth the seeking. A half century in his chosen line of work had given him a training and experience, had developed a power of judgment and appraisal that rarely went astray, and this judgment was freely placed at the service of all who asked.

New Publications

Books, Bulletins, Catalogues, Etc.

Hanna Stoker Catalogue. The Hanna Stoker Co., of Cincinnati, Ohio, have issued a 20 page illustrated catalogue of 8½ in. by 11 in., or letter head size. It is printed on highly calendared paper and its illustrations are remarkably clear and distinct. On its title page is a quoted sentence that reads: "Absolute coal control—more flexible than the man with the scoop." In the foreword the aims of the designers are set forth as a desire to meet the requirements of the committee on mechanical stokers of the American Railway Association that "the stoker should distribute the coal in the firebox in such a manner as to call for no assistance from the fireman other than the regulation of the supply and possibly the adjustment of the mechanical appliances for distribution." And the claim is made that this requirement has been amply met.

The illustrations show the Hanna stoker as a whole and in detail from many points of observation, and each is accompanied by a brief description. Then follow illustrations and dimensional descriptions of fifteen heavy locomotives on eight railroads to which these stokers have been applied, and the pamphlet closes with an illustration of the original Hanna stoker of 1910, which had a hopper in the cab into which the coal was shoveled by the fireman, and which is claimed to have been the first successful stoker, whose distribution has never been excelled. It was applied to an engine of the Cincinnati, New Orleans & Texas-Pacific Ry. (Queen & Crescent).

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

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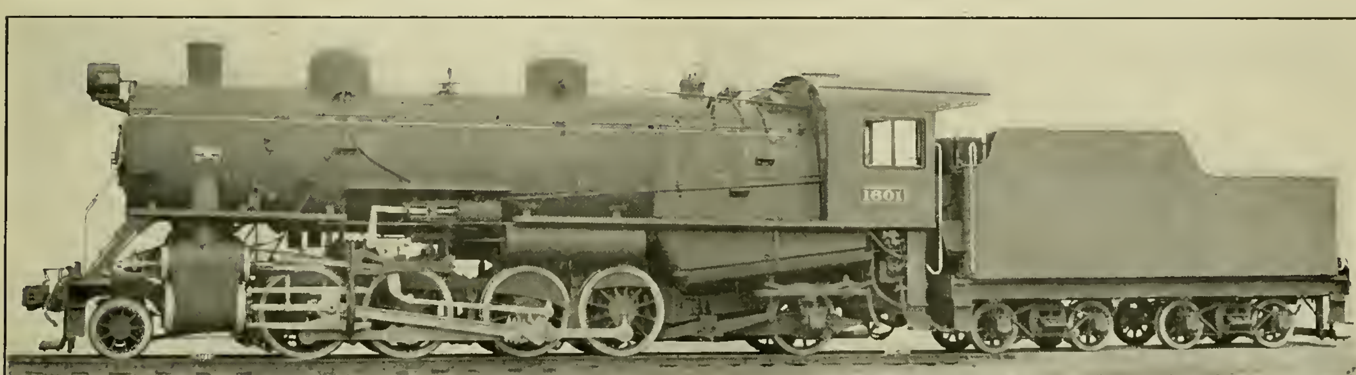
Three-Cylinder Locomotive for the South Manchurian Ry.

Some of the Interesting Details Embodied in a Design of the American Locomotive Company

There is nothing new in the special cylinder arrangement of the three-cylinder locomotive. That method of increasing the efficiency of the machine was proposed and built years ago, both in the simple and compound form. So that the novelty of the design here shown is merely that it embodies the latest and most improved construction.

Five of these locomotives have recently been built for and delivered to the South Manchuria Railway, a sketch of whose conditions appears in another column. They are of the Mikado (2-8-2) type and have the following principal dimensions:

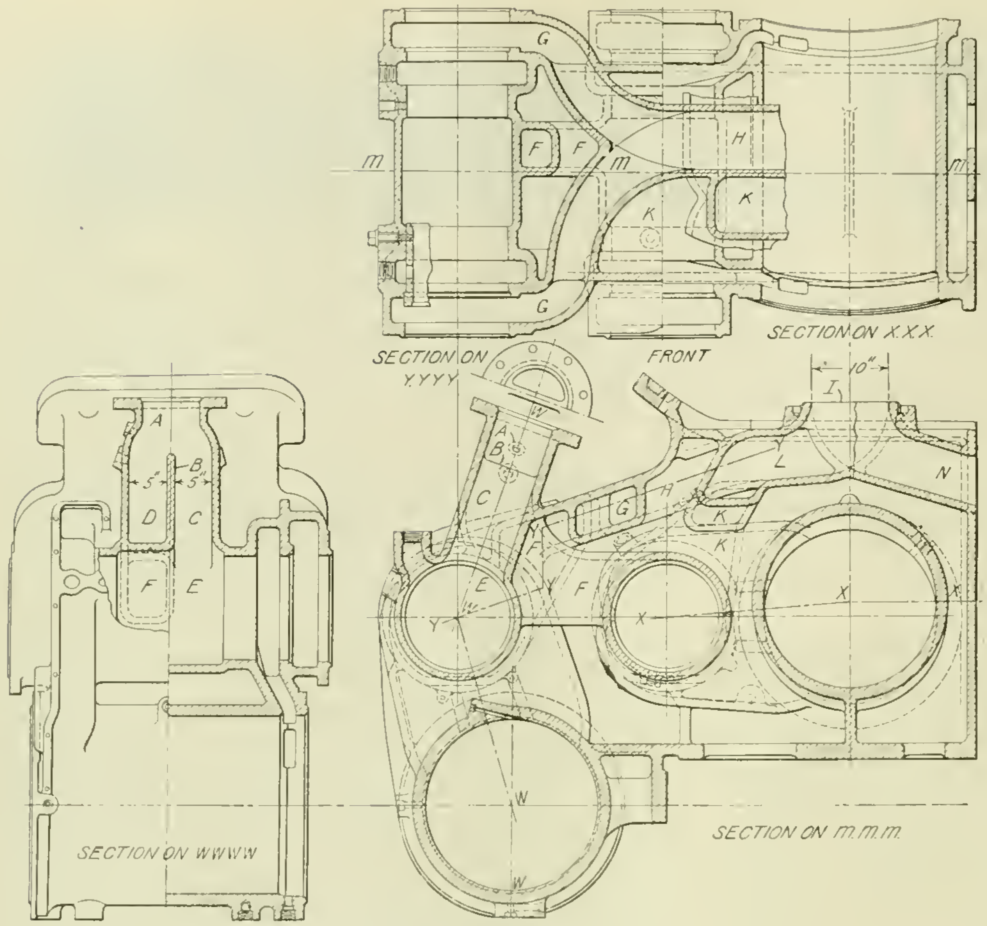
Gauge of track	4 ft. 8½ in.
Fuel	Bituminous coal
Thickness of crownsheet	⅜ in.
Thickness of tubesheet	½ in.
Thickness of side and back sheets	⅜ in.
Water space, front	5 in.
Water space, sides and back	4½ in.
Distance, top of grate to center of lowest tube	24½ in.
Tubes, number	245
Tubes, diameter	2 in.
Tubes, length	18 ft. 6 in.
Superheater tubes, number	42
Superheater tubes, diameter	5⅜ in.
Heating surface, tubes	2,361 sq. ft.
Heating surface, superheater tubes	1,088 sq. ft.
Heating surface, firebox	217 sq. ft.



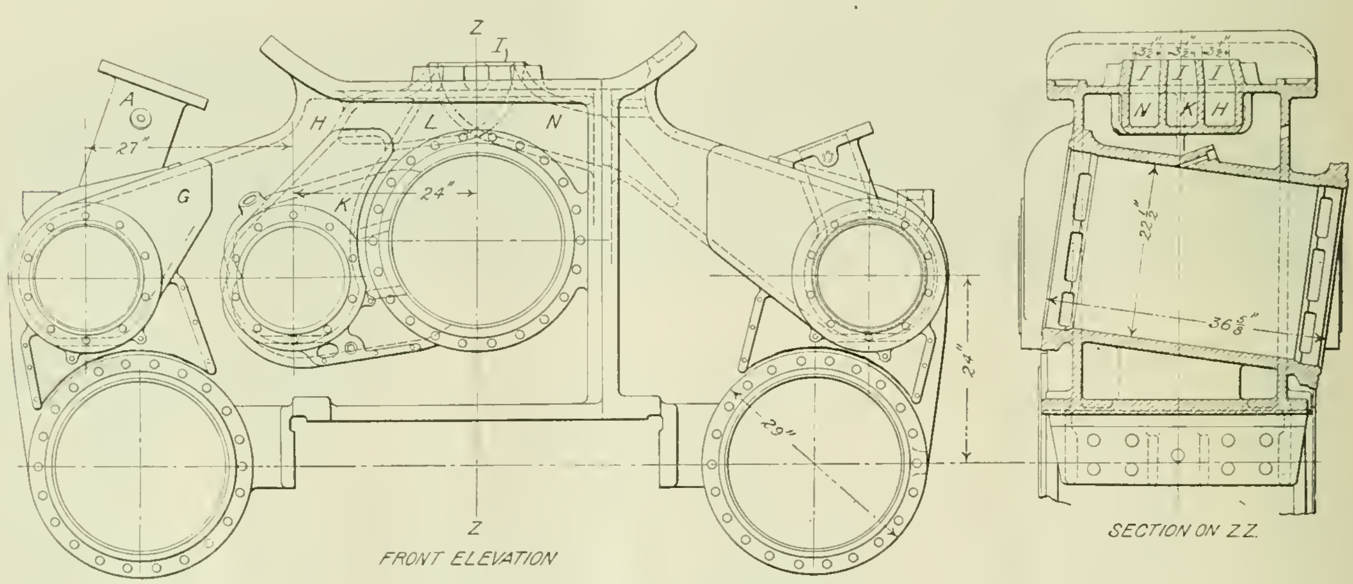
Three-Cylinder Mikado Type Locomotive for the South Manchurian Railway

Cylinder diameter	22½ in.
Piston stroke	26 in.
Tractive power	56,000 lbs.
Factor of adhesion	3.47
Wheelbase, driving	15 ft. 10 in.
Wheelbase, total engine	34 ft. 2 in.
Wheelbase, engine and tender	62 ft. 7¼ in.
Weight in working order	268,000 lbs.
Weight on drivers	194,200 lbs.
Weight on front truck	25,000 lbs.
Weight on trailer truck	48,800 lbs.
Weight of engine and tender	403,000 lbs.
Steam pressure	180 lbs.
Firebox length	114⅛ in.
Firebox width	84¼ in.
Heating surface, arch tubes	29 sq. ft.
Heating surface, total	3,695 sq. ft.
Grate area	66.8 sq. ft.
Diameter driving wheels	54 in.
Diameter front truck wheels	33¼ in.
Diameter trailing truck wheels	44 in.
Diameter tender truck wheels	33¼ in.
Smoke stack diameter	17 in.
Tender capacity, water	6,000 gals.
Tender capacity, coal	12 tons

The engines are purely of the American type with the notable exception that the engineer is located upon the left hand side of the machine instead of the right. Other than this, and the fact of there being three cylinders



Vertical and Horizontal Sections of Cylinders of Three-Cylinder Locomotive of South Manchurian Railway



Front Elevation and Section of Center Cylinder of Three-Cylinder Locomotive

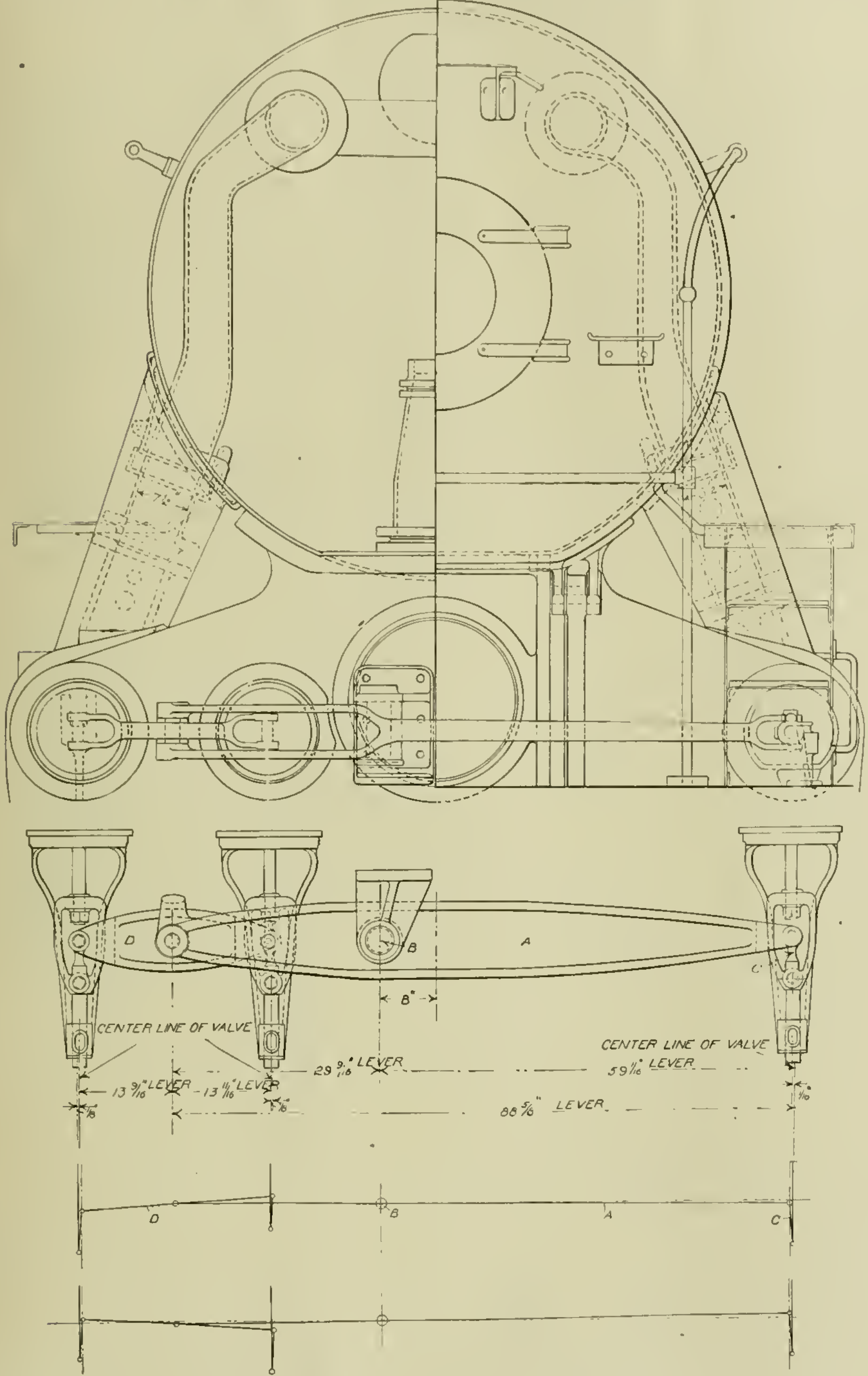
instead of two they would hardly attract more than a passing glance in this country. They are, however, possessed of a number of interesting details. First among these are, of course the cylinders. These are in two pieces as usual, but instead of each being cast with a half saddle and made interchangeable for right or left hand service, the whole saddle, in which the central cylinder is located is cast integrally with the right hand cylinder, and the left hand is bolted to it. The large casting also contains the two steam chests of the right and central cylinders. The two outside cylinders are horizontal and the central is inclined downward from front to back at an angle of 8 degrees, and has the center of its front end elevated about 28¾ in. above the center line of the two outside ones.

The centers of all of the steam chests are in one horizontal plane which is situated 24 in. above that of the outside cylinders.

Steam is conducted to the steam chests by two steam pipes, in the smokebox of the ordinary type. That feeding the right hand and central cylinder being 7½ in. in diameter and that leading to the left hand cylinder 6½ in. They turn out through the sides of the smokebox 20 in. below the center of the same and are coupled to a short length of pipe, fitted with the ordinary ground joints, which serves as an intermediate between them and the flanges on the cylinder casting. The ratio of the sectional areas of these two pipes is as one to 1.142. The steam is led to the central portion of the steam chests, as the valves are of the inside admission type, and, from the ends, it goes to a common exhaust at the center of the saddle.

In the left hand cylinder the passages are of the ordinary form; but in the large casting there is a greater complication due to the necessity of preventing the exhaust from one cylinder backing into the other. It is, in order to show the skill with which these passages have been worked out and located that very complete illustrations of this casting are given.

The steam entering the flanged connection at *A* is divided into two streams by the partition *B*. One stream flows down through the passage *C* directly to the central portion of the steam chest of the right hand cylinder at *E*, both of these passages being 5 in. wide. It will be noticed that the passage *E*, as it enters the steam chest,



Front Elevation of Three-Cylinder Locomotive and Arrangement of Valve Motion Levers

does so off center. That is one edge of the passage is off center by half the thickness of the partition *B*.

The steam entering the passage *D* follows it down to the shell of the outside steam chest, where it curves over the top of the same with the passage *F* which it follows to the central space in the steam chest of the central cylinder, entering on the other side of the center line from that which the passage *C* enters the outside cylinder.

The exhaust passages *G* from the ends of outside cylinder rise to the upper surface of the casting and curve inward toward the center, uniting in the passage *H* which curves up to the opening *I* beneath the blast pipe, and back of a similar opening for the exhaust from the central cylinder.

The corresponding exhaust passages *K* for the central steam chest rise in the same manner and unite in the single passage *L* which runs alongside of *H* and rises with it, but in front of it, to the exhaust opening *I*.

The steam and exhaust passages of the left hand cylinder admit of the usual arrangement which is much simpler. The steam passage drops directly down from the steam pipe to the center of the steam chest, while the exhaust passages, rising from the ends, curve around it and after uniting in a single passage, connect with the passage N in the saddle which rises to a discharge point at *I* in front of the other two.

This arrangement gives three independent rectangular exhaust openings into the blast pipe for the three cylinders respectively, that measure 10 in. by 3½ in. In this the exhaust from the central cylinder is in the middle with that from the left at the front and that from the right at the back.

Of course, the usual precautions have been taken to maintain a uniformity of thickness of metal throughout the whole casting so as to avoid undue shrinkage strains.

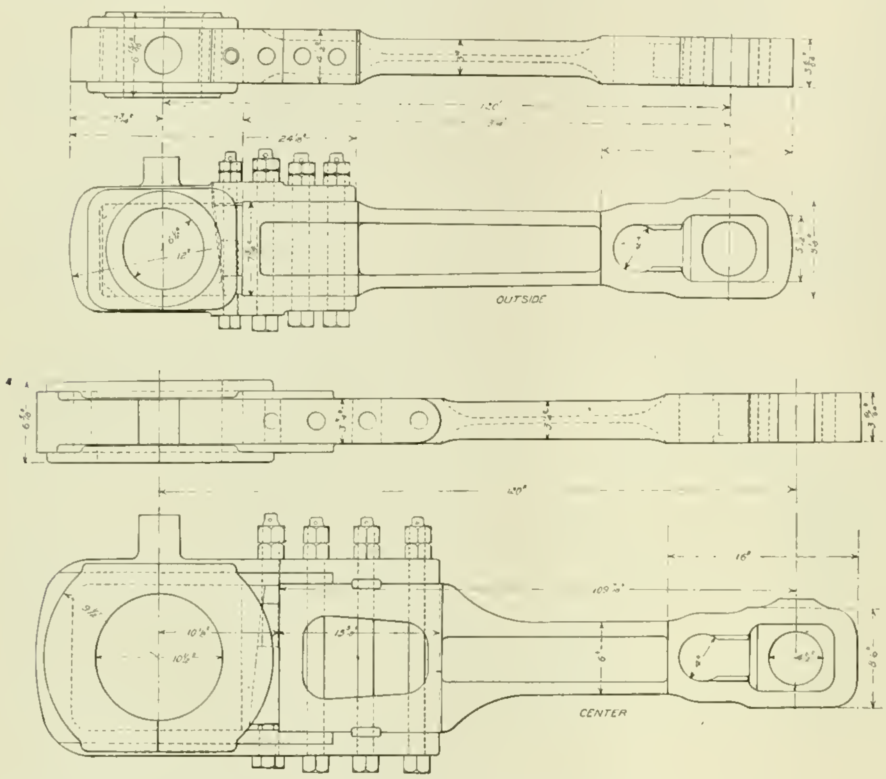
Closely associated with the cylinders is the vitally important valve gear. The Walschaerts motion is used for the two outside valves. As already stated, this is arranged to give inside admission for the valves, which are 12 in. in diameter and have a travel of 6 in. They have an outside lap of 1⅛ in. and are set for a lead of 3/16 in. with the exhaust edges set line and line.

Owing to the lack of space between the frames the valve for the central cylinder is driven by a system of levers connected to extensions of the valve stems of the two outside cylinders.

The arrangement of these levers is shown by the engraving. The longer *A*, which is a steel casting, is pivoted at *B* on a bracket bolted to the saddle and set 8 in. off center. The long arm of the lever is attached by means of connection *C* to the valve stem of the left hand cylinder, while the short arm is pivoted to small lever, *D*, connected at its ends to the valve stems of the right hand and central cylinders respectively. The ratio of length of the long and short arms of the large lever is nearly as one to 2; the long arm lacking only 1/16 in. of meeting this ratio. The two arms of the short lever are of nearly equal lengths there being but ⅛ in. difference between the two. This variation from the exact ratios serves to compensate for the angularity of the rods and connections in securing an accurate operation of the valve of the central cylinder.

If we consider the crank of the right hand cylinder as the leading one, when running forward, it is followed, successively by the left hand and the central crank.

The position of the valve levers, when the piston of the central cylinder is at the end of its stroke is shown by the diagrammatic sketch. In each case the valve will be seen to have been moved out of its mid position by the sum of its lap and lead or 1-5/16 in. The movement of the small lever *D* is similar to that of the lap and lead lever of the Walschaerts gear. For as the latter is moved by the combination of the union bar and the radius rod, so the former is moved by the combined action of the two outside valve stems.



Outside and Center Connecting Rods for Three-Cylinder Locomotive

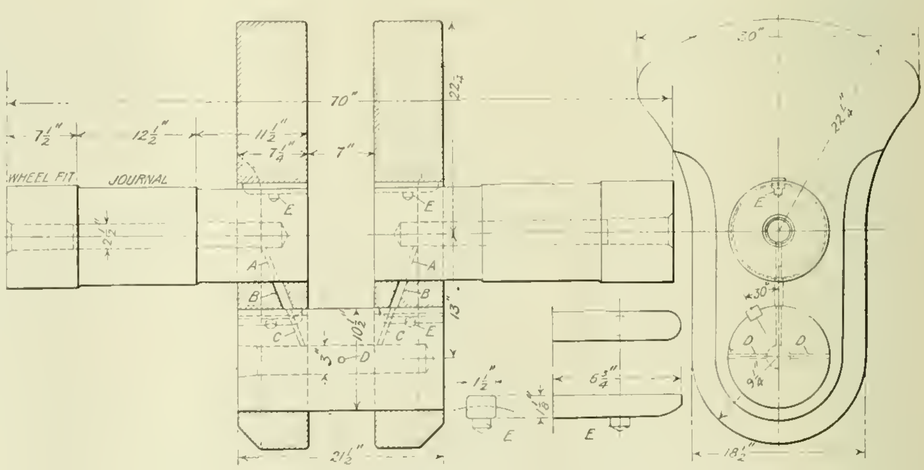
The main rods are of the usual *I* section with solid ends for the wrist pins and straps for the crankpin ends. The outside rods have a depth of 7¾ in. at the stub ends for the crankpins which are 6½ in. in diameter. The center rod has a corresponding depth of 12¼ in. and the crankpin has a diameter of 10½ in. This rod, however, has no greater depth of body in its central portion than the outside rods. It is 6 in. deep and, instead of being tapered, it is straight through the *I* section. All of these rods are 120 in. from center to center. Now, because of the elevated and inclined position of the center cylinder, the center rod would strike the second driving axle if it were to be made straight. That axle has, therefore, been given an offset of 5½ in. as shown, it being placed in the wheels so as to have its offset correspond with the pin of the crank axle, and thus insure a clearance when the rod is in its lowest position.

One of the most important details associated with the central cylinder is the crank axle. Its unreliability, as then manufactured, was one of the leading causes for its abandonment on early American locomotives. In a paper on the subject of the three-cylinder locomotive, presented by Mr. J. G. Blunt, mechanical engineer of the American Locomotive Co. before the Mechanical Division of the American Railway Association last June, he said that, before building these engines, "a very thorough investigation was made in order to decide as to whether a solid forged or built-up crank axle was most advisable. Simplicity of manufacture together with better service reports, resulted in the adoption of the built-up axle, which, at the same time, facilitates balancing the reciprocating weights of the middle cylinder in the crank discs.

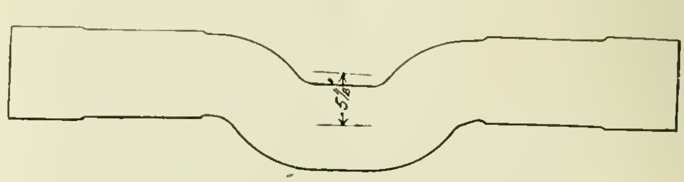
"In answer to inquiries from several sources, as to how the middle crankpin might be trued if found necessary," he said, that "machines are now on the market for easily performing this operation," one of which is illustrated and described in another column of this issue.

"Chrome vanadium steel is used for all of the component parts of this crank axle, except the crank discs which are of carbon vanadium steel and grease lubrication is applied through the center of the axle to the crankpin, with grease plugs in the outer ends of the axle."

Referring to the illustration of the axle, it will be seen to be composed of two short lengths of axle, two crank discs and the crankpin, all held together by a shrinkage fit and 1½ in. by 1⅛ in. keys. The two axle pieces are each 2 ft. 7½ in. long with a maximum diameter of 10½ in. at the wheel fit. An axial hole 2½ in. in diameter is drilled to a depth of 2 ft. 5 in. This hole is tapered to a depth of 8 in. at the outer end on a taper of ⅜ in. to the foot and in it the grease plug is inserted. Near the inner end a ½ in. diameter hole *A* is drilled that mates with a ⅞ in. diameter hole *B* in the crank disc; which, in turn, leads



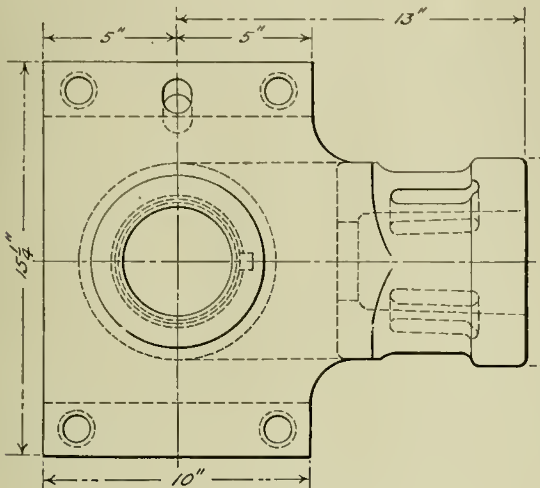
Built-Up Crank Axle for Three-Cylinder Locomotive


Offset Axle for Second Pair of Drivers

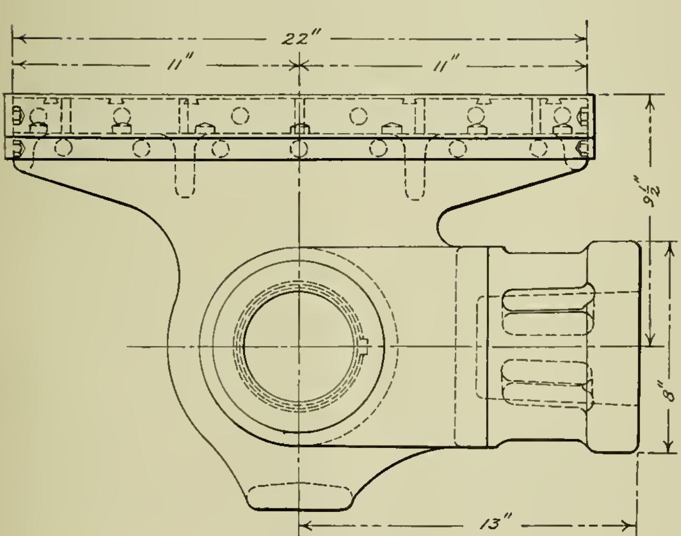
to a ½ in. hole *C* in the crankpin, that delivers the grease to a 3 in. axial hole in the pin. This hole is closed at its outer end by a plug which is screwed in tight and welded, and delivers the grease to the surface through the ½ in. hole *D*.

The keys, of which one is shown in detail, by which the discs are held to the axle and the crankpin, are of rectangular section 1½ in. by 1⅛ in. and are fitted with a dowel pin *E* which enters a corresponding hole in the keyway cut in the axle and crankpin. The inner end is cut on a curve of 2½ in. radius to fit that of the keyway as cut by the miller.

The whole crank axle is finished all over.



ALLIGATOR CROSSHEAD



LAIRD CROSSHEAD

Crossheads for Three-Cylinder Locomotive

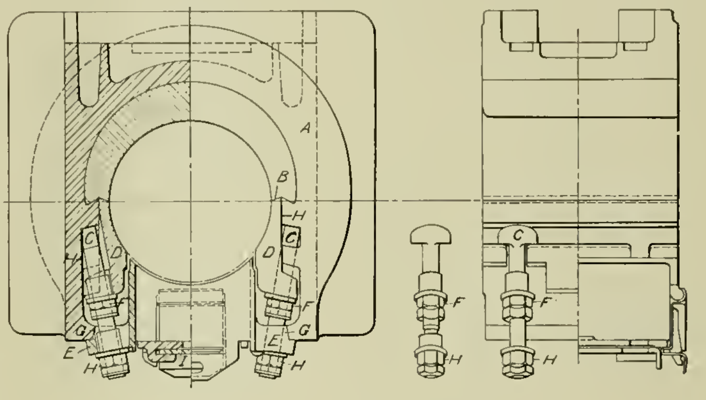
Two types of crosshead are used. For the outside cylinders there is the ordinary alligator with two-bar guides. For the central cylinder, the Laird type with the three-bar guide is used. Mr. Blunt, in the paper already referred to, gives as a reason for this that "the best service has resulted from the use of the three-bar type of crosshead having approximately a 50 per cent increase in bearing surface over that used for either of the outside crossheads. The available clearance space readily permits of this increase and the desire to reduce maintenance to a minimum has been fully substantiated by using this type of crosshead.

Attention is called to the difference in the lengths of the bearing surfaces of the two types that of the Laird being 22 in. while that of the alligator is but 10 in.

According to Mr. Blunt's paper "a thorough analysis of the forces obtaining in the three-cylinder application, together with the operating experience thus far gained, showed most beneficial results from the use of supplementary bearings on both sides of the driving journal and projecting from 2½ in. to 3 in. below the center of the axle."

A driving box spreader, open at the bottom and through which the grease is applied, is drawn into position to prevent the sides of the box from closing in due to cylinder thrust and in turn, pinching the journal brass on the axle with consequent heating of journals.

The supplementary bearings, as well as the spreader, when once drawn into position, should not require removal until the wheels are dropped to perform work on main journal bearings or boxes. The pedestal tie is curved downwardly sufficiently to allow removal of the grease plate, as well as replacement without loosening pedestal tie bolts. The grease plate is held in place by a plate spring so formed that when entering a groove in the spreader, it securely supports the grease plate, thus overcoming vibration and wear of parts. The locomotive



Main Driving Box of Three-Cylinder Locomotive

must of necessity be spotted with the crank disc approximately horizontal before removing grease plate.

Referring to the engraving of the driving box, the main body *A* of box is essentially the same in shape as the one in common use and the crown brass is put in in the same way, but it projects inwardly from its footing about ⅝ in. and is beveled downward at *B*. Just below its footing the metal of the box is cut away to form a shelf for the bearing of the T headed bolt *C* by which both the supplementary bearings *D* and the spreader *E* are held in place. The supplementary bearing has an inclined hole 1½ in. in diameter running up through it, and it is beveled at the top to meet the corresponding bevel *B* of the crown brass. The nut *F* on the T bolt has a collar that fits into the hole in the supplementary brass by which the latter is made fast to the bolt. The brass is held up to the axle by the surface *H* which is finished and by the beveled surface *B* at the foot of the crown brass. The tightening nut *F* with its collar is held by a check nut as shown.

The spreader *E* slips up into the opening in the box casting and is held firmly against the beveled surfaces *G* by the lower nuts *H* of the T headed bolts. The spreader itself has the general form of the ordinary cellar but without a bottom. In this case the bottom *B* slides into place from below and is held in place by a support *I* that is slipped in from the side.

With this construction, the journal has an ample support on the sides and yet all parts are readily accessible for repairs.

The following is a list of some of the specialties that have been used on these engines:

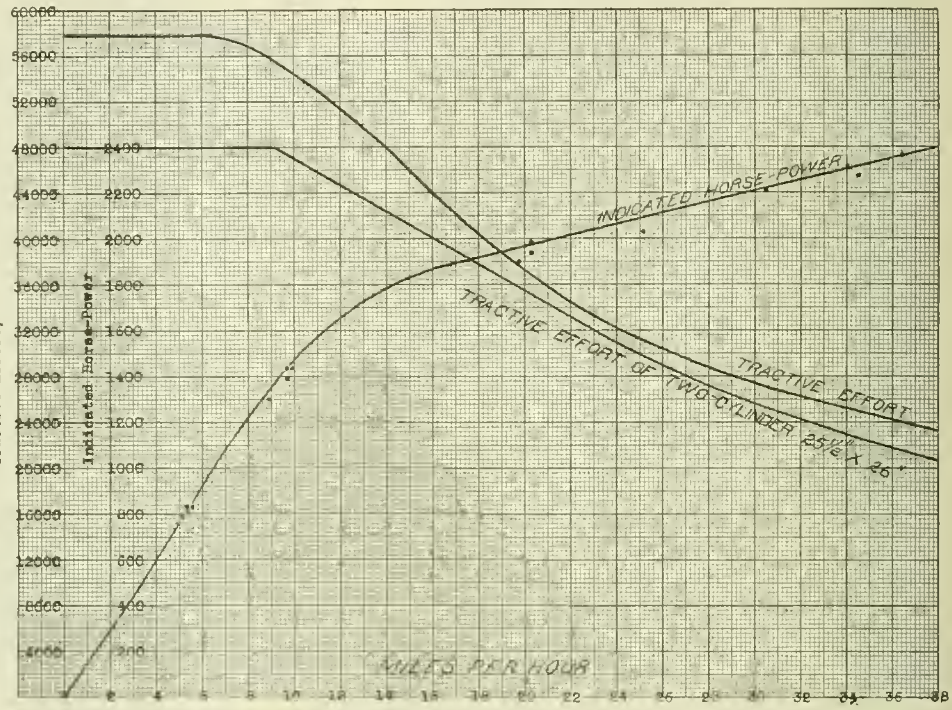
Superior flue blower on one engine, Viloco bell ringer, Franklin power grate shaker, Franklin Butterfly firedoor, Pyle National headlight, Okadee water gauges, Chambers outside connected throttle in dome, Viloco pneumatic double sanders, Franklin unit drawbar, I.c., Ashcroft steam gauge, Gibson retaining rings, Okadee blow off cocks, Okadee blower valves, Tender hose coupling, Radial buffer, Alco staybolts, Overlasting safety valves, Simplex injectors, Elvin mechanical stoker, Alco reverse gear, Paxton Mitchell rod packing, Elvin grease cellars, Nathan lubricator, Westinghouse-American combined automatic air brakes.

We may now turn to the performance of the engine in some of the tests to which it has been subjected.

The accompanying diagram shows the tractive effort and indicated horsepower of one of these South Manchurian locomotives as compared with the tractive effort developed in a two-cylinder locomotive having cylinders 25½ in. in diameter and a piston stroke of 26 in.

In making this comparison it must be borne in mind that the ratio of the combined cylinder capacities of the three-cylinder locomotive was as 1518.75 to 1300.50 for that of the two cylinder locomotive or 16.78 per cent. more.

The diagram is carried out to a speed of 38 miles per hour at which point the tractive effort of the two-cylinder locomotive was 20,800 lbs. and that of the three-cylinder, 23,400 lbs. or 12.5 per cent more than the former. At the point of nearest approach of the two lines, that is at a speed of 22 miles an hour, the tractive effort developed by the two-cylinder locomotive was 31,000 lbs. while that developed by the three-cylinder was 32,600 lbs. or 5.16 per cent. more. At starting and up to a speed of 6 miles per hour, the two-cylinder locomotive developed a tractive effort of 48,000 lbs. and the three-cylinder 57,800 lbs. though it is scheduled for but 56,000 lbs. This shows a starting superiority over the two-cylinder machine of about 20.42 per cent.



Tractive Effort of the Three-Cylinder Locomotive of the South Manchurian Railway Compared With That of the Two-Cylinder Arrangement with the Factor of Adhesion of 4.05

Four sets of indicator cards are here shown: one with the reverse lever in full gear and the engine running at a speed of 5.45 miles per hour, and two with a 50 per cent. cut-off and the engine running at 14.76 and 34 miles per hour respectively, and one with a 33 per cent. cut-off running at 33.4 miles per hour.

In the first case, where the valve motion was in full gear, the horsepower developed by the central cylinder was about 5 per cent. less than the average of the two outside cylinders. At 14.76 miles per hour and a 50 per cent. cut-off it became about 2.65 per cent. more and at 34 miles per hour and the same cut-off it was 12.4 per cent. more. While, when the cut-off was reduced to 33 per cent. and the speed held at 33.4 miles per hour the central cylinder developed 40.32 per cent. more than the average of the other two. At the same time there was a steady increase in the difference between the horsepower developed in the two outside cylinders as the cut-off was shortened and the speed increased up to 50 per cent. cut-off and 34 miles per hour; but, when the cut-off was still further reduced to 33 per cent., the difference between the two was decreased.

These cards may be considered as truly comparable as the boiler steam pressure varied only from 178 to 180 lbs. per sq. in.

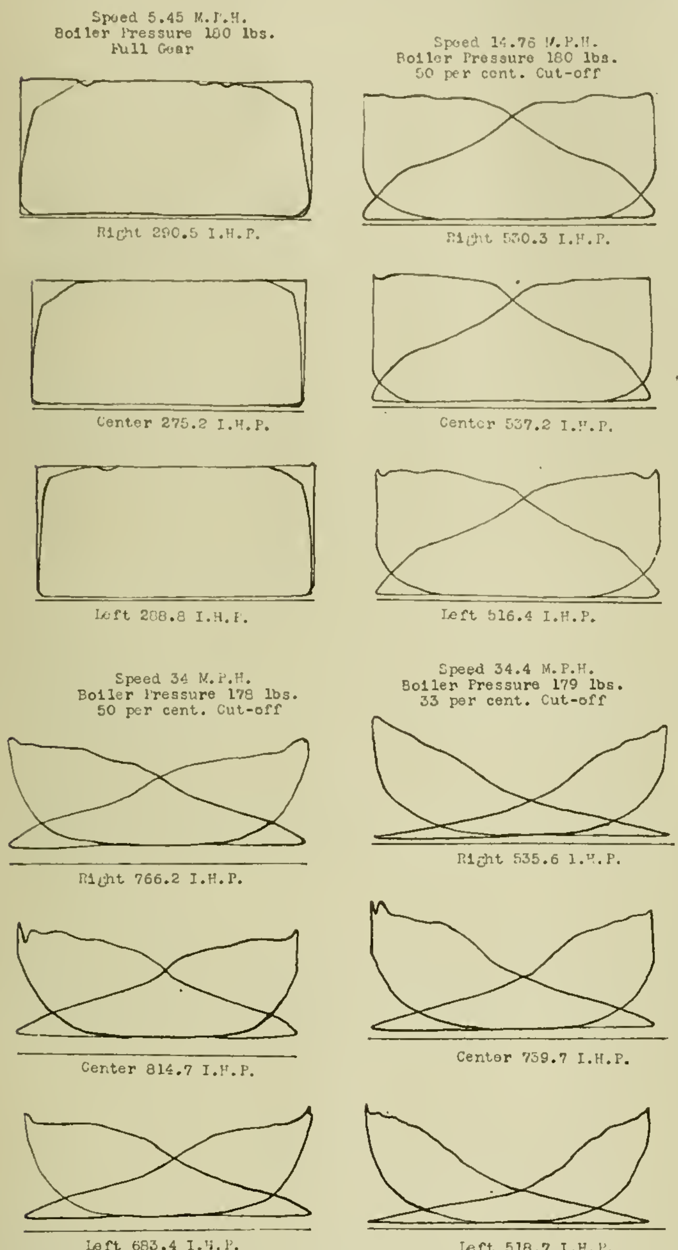
The variation in the horsepower developed in the three cylinders is no greater than will be found in engines in everyday service. The proper designing and adjustment of a valve motion is a delicate matter, and how well this has been accomplished in this instance is shown by the accompanying tabulation of valve events. Let us take the forward motion figures for the four series of indicator cards that are reproduced.

In full gear, the lead is the same in all three cylinders, except that the front end of the right hand cylinder has an excess over the others of 1/64 in. The port openings only vary 7/64 in. except in the case of the front end of the right hand cylinder which is about 3/16 in. less than the average of the others. The points of cut-off are remarkably uniform with the central cylinder about ⅝ in. or a little less than 3 per cent. later. The same relation holds true for the release and the valve closure; all showing a remarkable evenness of adjustment.

At a cut-off of 50 per cent. the port opening of the central cylinder has taken a definite lead over the other two, which are about the same. The cut-off is practically the same at each end of each cylinder. On the release the central cylinder still drops back of the other two, with all three nearly equalized between the two strokes.

At a cut-off of 33 per cent., we still have the same constant lead, and very little variation in the amount of port opening either between the cylinders or between the two ends of the same cylinder. The cut-off, however, shows an average of 7 ⅝ in. for the right hand cylinder, 7 11/16 in. for the left hand and 8 11/32 in. for the central or an increase of nearly 6 per cent. over the average of the other two. This with the later average release of about ½ in. is the probable explanation of the considerable increase of horsepower shown to have been developed by the central cylinder over the other two. An explanation that cannot be fully developed, however, without of a full valve ellipse which is not yet available.

There is one point in this tabulation that needs a little explanation. Ordinarily where there is a lead there must



Indicator Diagrams from Three-Cylinder Locomotive of the South Manchurian Railway

be a preadmission. The reason for putting the latter at zero for full gear in the tabulation is that the amount of pre-admission is less than 1/64 in. and so was considered negligible as it is.

Enough has been said in regard to the tabulation to show how carefully this combination valve motion has been worked out in order to get such remarkably uniform results, not only in the two ends of each cylinder, but in the three cylinders as compared with each other.

In the issue of Railway Locomotive Engineering for June, 1924, a description was published of the otheograph of the General Electric Company at Erie, Pa., by which the vertical and lateral thrusts of the wheels upon the rails are measured and recorded.

One of these South Manchurian locomotives was run over the apparatus at varying speeds and the results recorded. Reproductions of otheographs taken at speeds of 5, 33 and 63 miles per hour are here reproduced. It will be noticed that the position of the crankpin evidently has, as it ought, an important influence on the vertical thrust.

Take the main driving wheel as an example. In the upper diagram at 33 miles per hour the main cranks was almost half way up as it passed the apparatus while the front and back crankpins were approaching the lowest

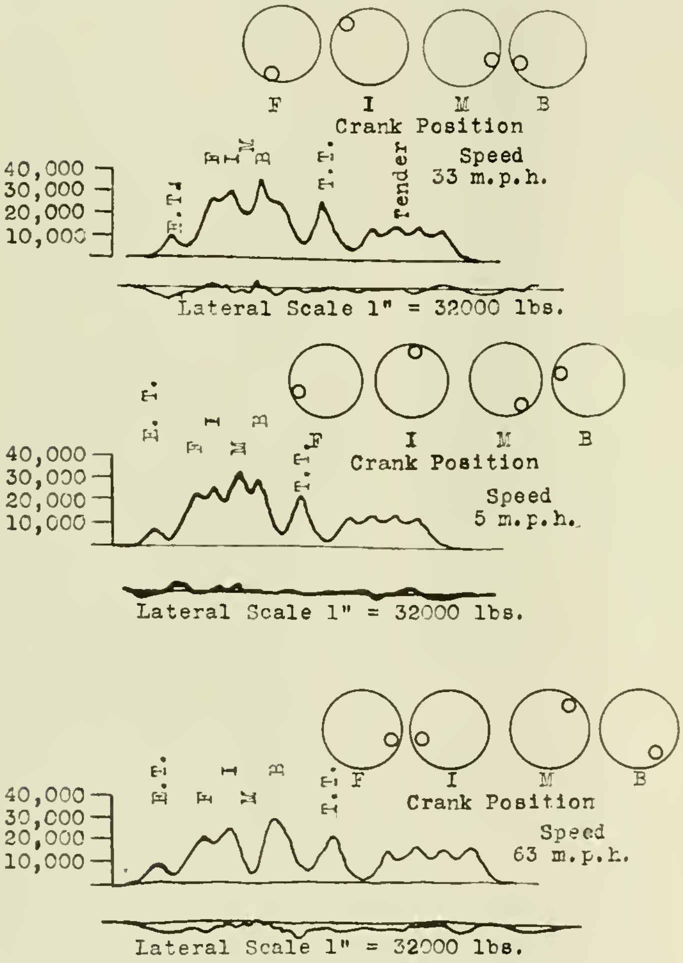
		Cut-off Position	Pre-admission		Lead		Port Opening		Cut-off		Release		Closure	
			Front	Back	Front	Back	Front	Back	Front	Back	Front	Back	Front	Back
Forward Motion	Right Hand Side	Full Gear	0	0	3/16	11/64	1 11/16	1 15/16	21 11/16	21 5/8	24 11/16	24 11/16	1 5/16	1 5/16
		66 per cent.	1/16	1/16	"	"	31/32	63/64	17 13/16	17 7/16	23 3/16	23 1/8	2 7/8	2 13/16
		50 " "	3/16	3/16	"	"	35/64	35/64	13 1/8	13	21 9/16	21 3/8	4 5/8	4 7/16
		33 " "	7/16	7/16	"	"	5/16	19/64	7 3/4	7 1/2	18 13/16	18 13/16	7 3/16	7 3/16
		25 " "	1/2	1/2	"	"	9/32	17/64	6 7/16	6 11/16	18 1/16	18 1/8	7 7/8	7 15/16
		20 " "	5/8	5/8	"	"	15/64	15/64	5	5 3/16	17 3/16	17 1/4	8 3/4	8 13/16
	Center	Full Gear	0	0	11/64	"	1 27/32	1 57/64	22 1/4	22 1/4	25 1/8	25	1	7/8
		66 per cent.	1/32	1/32	"	"	1 1/32	1 3/64	17 3/4	17 3/4	23 7/8	23 7/8	2 1/8	2 1/8
		50 " "	1/16	1/16	"	"	19/32	21/32	13	13	22	22 1/8	3 7/8	4
		33 " "	3/16	3/16	"	"	5/16	23/64	8 1/4	8 7/16	19 1/8	19 3/8	6 5/8	6 7/8
		25 " "	1/4	1/4	"	"	9/32	5/16	7 7/8	7 5/8	18 1/2	18 3/4	7 1/4	7 1/2
		20 " "	5/16	5/16	"	"	15/64	1/4	6 1/4	6 1/4	17 1/2	17 3/4	8 1/4	8 1/2
	Left Hand Side	Full Gear	0	1/32	3/16	"	1 53/64	1 29/32	21 5/8	21 9/16	24 5/8	24 11/16	1 5/16	1 3/8
		66 per cent.	1/16	1/16	"	"	61/64	63/64	17 3/4	17 3/4	23 1/8	23 1/8	2 7/8	2 7/8
		50 " "	1/4	1/4	"	"	35/64	17/32	13 1/16	13	21 1/2	21 7/16	4 9/16	4 1/2
		33 " "	1/2	7/16	"	"	19/64	19/64	7 3/4	7 5/8	18 3/4	18 3/4	7 1/4	7 1/4
		25 " "	5/8	9/16	"	"	17/64	17/64	6 1/2	6 5/8	18	18 1/16	7 15/16	8
		20 " "	13/16	11/16	"	"	15/64	15/64	4 7/8	5 1/4	17 1/8	17 1/4	8 3/4	8 7/8
Backward Motion	Righthand Side	Full Gear	0	0	"	"	1 57/64	1 59/64	22 1/4	21 5/16	24 11/16	24 5/8	1 3/8	1 7/16
		50 per cent.	5/32	1/8	"	"	37/64	19/32	13 1/2	13 3/8	21 13/16	21 9/16	4 7/16	4 3/16
		33 " "	5/16	5/16	"	"	23/64	23/64	8 11/16	8 7/8	19 1/2	19 1/2	6 1/2	6 1/2
		25 " "	1/2	7/16	"	"	19/64	9/32	6 5/8	6 7/8	18 1/8	18 3/16	7 13/16	7 7/8
	Center	Full Gear	0	1/16	11/64	"	1 23/32	1 53/64	21 5/8	22 9/16	24 3/4	25 1/4	3/4	1 1/4
		50 per cent.	1/32	1/16	"	"	37/64	21/32	13 1/2	13 5/8	22 1/8	22 1/8	3 7/8	3 7/8
		33 " "	1/8	1/8	"	"	5/16	3/8	9 7/16	9 1/2	19 7/8	19 3/4	6 1/4	6 1/8
		25 " "	3/16	3/16	"	"	15/64	17/64	7 3/8	7 1/2	18 1/2	18 1/2	7 1/2	7 1/2
	Lefthand Side	Full Gear	1/32	0	3/16	"	1 55/64	1 59/64	22 1/4	21 1/2	24 7/8	24 9/16	1 7/16	1 1/8
		50 per cent.	5/32	1/8	"	"	37/64	37/64	13 1/2	13 1/4	21 15/16	21 9/16	4 7/16	4 1/16
		33 " "	5/16	1/4	"	"	23/64	11/32	8 13/16	8 13/16	19 5/8	19 1/2	6 1/2	6 3/8
		25 " "	7/16	1/2	"	"	19/64	9/32	6 13/16	6 3/4	18 7/16	18 1/4	7 3/4	7 9/16

Valve Events Three-Cylinder Locomotive

point. The result was that both recorded greater pressures than the main driver. In the second diagram the main driver crankpin had just passed its lowest position while the others were away from it. In this at 5 miles per hour, the main driver exerted a greater downward thrust than any of the others. In the lower one at 63 miles per hour the main driver with its crankpin nearing the upper position, the downward thrust was only about 5,000 lbs. as measured by the scale at the left; whereas at 5 miles per hour it was about 34,000 lbs.

It must be borne in mind, however, that while the diagram may show the true downward impulse on the otheograph spring, it does not follow that it is all due to the particular wheel that happens to be over it. This is because the running rail is carried solidly across the length of the apparatus and though it is supported independently at 2 ft. intervals, it is hardly possible that its rigidity does not serve to transfer a portion of the load imposed by one wheel both forward and backward to the instrument that is directly beneath the wheel ahead or back of it. So that it can hardly be depended upon to accurately measure the impact of any one wheel.

The scale indicating the lateral thrust is about 1,000 lbs. to each 1/32 in. so that it is too fine to make it



Otheograph Records of Three-Cylinder Locomotive for South Manchurian Railway

possible for an accurate analysis of these thrusts to be made from it.

In making these runs on the experimental track of the General Electric Co., though the work was done without the usual breaking in, there was no indication of heating at any time, even when the speed was forced up to 63 miles per hour, which was equivalent to a piston speed of 1,700 ft. per minute. At this speed, too, there was no indication of rough riding in the cab and, as will be seen from an examination of them, the otheograph records indicate a remarkable lateral steadiness or freedom from nosing, a maximum lateral thrust of 5,000 lbs. being observed, which was attained at a speed of 63 miles per hour, that at 33 miles per hour having been but 3,000 lbs.

The rapid acceleration of the engine as compared with the two-cylinder type was just as much in evidence in this engine as in the previous three cylinder engines built, the full stroke cards showing admirable starting conditions.

A slight irregularity in the valve setting of all the cards will be noted, but it must be remembered that these cards were taken with the setting just as turned out from the shop, there being no opportunity to make the final adjustments before the tests. Even so, the specimen cards show very good equalization of power under the circumstances, and there seems little doubt but that this engine is the most remarkable locomotive of its size and general proportions that the American Locomotive Company has built both as regards power and flexibility.

It is unusual to find a locomotive primarily designed for freight service, with small wheels and long maximum cut-off, to be able to exceed the diameter-speed, yet this engine, with only 54 inch diameter wheels, easily attained a speed of 63 miles per hour with only about two miles run to accelerate.

In a short time there will be a sufficient number of these three-cylinder locomotives in service, both in this country and abroad, to make a thorough analysis of their performances possible. But, the very fact that repeat orders are already being placed for them, would indicate that they are rending a satisfactory service.

New Switching Locomotives for the Pennsylvania

Orders have just been placed at Altoona Works of the Pennsylvania Railroad for the construction of fifty-eight wheel switching locomotives of an entirely new design, to be known as the Class C-1. The principal features of these locomotives will be: Cylinders 27 inches diameter by 30 inches stroke, steam pressure 250 pounds per square inch, driving wheels 56 inches diameter, weight of locomotive in working order (estimated) 275,000 pounds, weight of tender loaded 128,000 pounds, tractive power 76,000 pounds.

When completed, we expect to publish a detailed description of the engine in the pages of Railway and Locomotive Engineering. The fifty under construction will be distributed to various points on the System where the traffic is of such a nature as to require a switching engine of the power indicated.

Extended Use of the Three-Cylinder Locomotive

The Lehigh Valley Railroad has ordered five three-cylinder locomotives from the American Locomotive Company which are duplicates of the No. 5000 type which was exhibited at the Atlantic City convention of the American Railway Association, and which was described in the April 1924 issue of Railway and Locomotive Engineering.

The American Locomotive Company has also announced an order for five Mikado type locomotives for the Wabash which are to be of the new three-cylinder type. The Delaware Lackawanna & Western have also ordered two three-cylinder locomotives of the Mountain type.

The American Locomotive Company have three-cylinder locomotives in operation or under construction for the Lehigh Valley, the New York Central, the New York, New Haven & Hartford, the Missouri Pacific, and the Wabash.

In another column of this issue there appears a detailed description of the three-cylinder locomotive of the South Manchurian Railway, five of which were recently shipped to this road by the American Locomotive Company.

Shop and Terminal Facilities Required for Railroad Mechanical Equipment*

By PAUL L. BATTEY, Consulting Engineer

In these days of high costs of labor and materials as represented in the large investment in equipment units and their maintenance, a comprehensive analysis of all of the factors involved in economic operation brings out some phases of the problem, rather outstanding, in the light of what has been considered common practice. It is essential that a proper balance between the ever-increasing size of locomotives and cars, and the facilities for maintaining and operating this equipment, be constantly in effect. This is further necessitated by the development and use of more intricately designed locomotives and heavier units in both locomotives and cars, to minimize the time the equipment is out of service.

It is this time element which I wish to stress, as the use factor of equipment is determined by it, and after all is said and done, the end of all economics is to maintain the highest possible use factor of equipment, which simply means keeping it in actual service on the road, together with reduction of man hours in maintenance, consistent with adequate service.

There are several factors involved in this result other than that of maintenance facilities, such as traffic and climatic conditions, as to which no two railroads are alike. Traffic charts have their peaks and depressions and any mechanical analysis as to maintenance facilities must be made having in mind traffic demands. Frequently advantage may be taken of seasonable fluctuations in traffic in the conduct of maintenance work, resulting in considerable saving in annual costs even though added investment be required.

The use factor of locomotives has been receiving more and more consideration by increasing mileage between terminals accomplishing material results. Consideration of such economics lie beyond the scope of this paper which is confined to improvements in use factor within terminals and repair shops, collectively of importance. Here, not only strict operating costs are involved but investment values as minimized by intelligent analysis of requirements and provision for future development.

It is the intention to describe briefly the scope of an analysis recently made for the Receiver, Mr. J. H. Young, of the Denver & Rio Grande Western R. R. System, in order that he could include in his budget for a general rehabilitation of the railroad as a whole, the terminal facilities and repair shops for the mechanical department so as to maintain the motive power and car equipment in first class operating condition.

The first problem was to ascertain the capital mileage in locomotives and cars as the equipment was found on the system. By capital mileage is meant the total available miles in each locomotive and car until its next general repair. To maintain rolling stock in par condition the same amount of mileage per annum should be restored by the shop facilities as is used in operation. In other words, shop facilities are merely the means of restoring used mileage except insofar as absolescence is concerned resulting in depreciation, requiring the application of more modern and efficient devices.

Locomotive Department Facilities

Taking up first the facilities for the locomotive department. These consist of course, both of the engine terminals and the repair shops. The terminal facilities are of great importance under present conditions, both from an operating and a maintenance standpoint because of necessity for balanced classified and running repairs while the repair shops are purely a matter of maintenance, except insofar as they effect the time of equipment in shop.

One important phase of this analysis was the determination of the time each motive power unit was actually on the road in service and the results indicated the condition which is usually found on other roads, that the actual use factor of a motive power unit to the operating department is between 20 and 30 per cent. A careful analysis of the distribution of locomotive hours in this case showed that approximately 65 per cent of engines were serviceable and balance 35 per cent unserviceable. Of the former, 15 per cent were in engine houses in the hands of mechanical department, 26 per cent in engine houses awaiting trains, 3 per cent at terminals and 20 per cent actually on the road or in yard switching service. Of the unserviceable 35 per cent, 5 per cent were waiting repairs, 24 per cent undergoing repairs in shops and engine houses and 6 per cent set aside as obsolete. These figures reflected the unusual condition during the shop strike for which allowances were made. With, roughly, a $50,000 investment represented in modern motive power units, plain economics demanded the provision of adequate terminal facilities for quickly returning an engine to service, including all possible repairs that can be economically made at the terminal, in order to keep the engine on the road making her expected mileage before general overhauling.

The proper distribution of the mechanical maintenance facilities of a railroad is a matter of increasing importance because of many present day conditions not formerly of so much weight. Decentralization has become almost a necessity because of labor conditions and the high investment represented per unit of equipment. Many years of observation indicate the favorable results of keeping each unit of power in service as long as possible by adequate running repairs before shopping for a general overhauling.

In the instance of the D. & R. G. W. the outcome of the analysis was the complete rehabilitation of their two principal repair shops located at the extreme termini of the road, at Denver and Salt Lake City, and extensive improvements in the terminal at Grand Junction, probably the most central point on the entire system. In fact, the analysis involved a careful study of the advisability of building an entirely new central repair plant at Grand Junction in lieu of the two existing plants at the east and west ends of the road. But the advantages were more than offset by disadvantages of greater weight.

However, the additions at Grand Junction were carefully located as the initial move towards a general repair plant at this point at such time as the Denver and Salt Lake City shop capacity is exceeded. The terminal facilities were improved by installation of new 110 ft. 450 ton, three-bearing turntable and lengthening the round house to properly take care of the new and larger engines contemplated for operation over the extended division from Denver. New drop pits were installed, together with modern heating and electric lighting installations. This, in conjunction with the new locomotive repair shop with a capacity and equipment for four heavy engines, includ-

*Abstract from a paper read before the Western Society of Engineers.

ing modern tools. Whiting locomotive hoist and crane service, provides for adequate and efficient handling of equipment on the division and makes it possible to realize on the economy of balancing the repair forces throughout the year as heavier repairs on several engines can be scheduled and carried on at this point, such engines being promptly returned to service.

Terminal improvements at two other points were also developed, one at Salida, Colorado, the junction point of the narrow gauge system with the standard gauge main line. Here roundhouse and terminal repair facilities were extended, this installation being approximately the same in repair capacity as at Grand Junction, similar equipment being provided. But provision is also made in this plant for the handling and repairs of narrow gauge engines, improvements including new and deeper section to the round house, together with modern boiler washing plant and steam heating system.

At Alamosa, Colorado, which is practically the center of gravity of the southern Colorado section of the road and narrow gauge lines, a very fair repair shop was in service, relatively better in character than at other points on the line. Principal improvements required here to bring the plant up to balanced condition was an extension to round house with boiler washing system and steam heating system, longer turntable, small extension to the repair shops, some new and modern tools and the changing of the old tools to be electrically driven throughout, with improvements to the power house. This constituted the betterments to the terminal facilities for motive power as determined by careful study of existing and future requirements.

Now as to the repair shops for general overhauling of power. The measure of capacity to determine the size of a locomotive shop should be the product of a tractive power unit and the locomotive miles consumed on the road for the reason that the weighted average of engine size must be considered with mileage to form a working factor. As before mentioned, it is necessary to put into the locomotives by renewals and repairs, the same number of miles that are taken out of them on the road. If for example, the total annual locomotive miles were 12,000,000 and the average tractive power of all locomotives making this mileage is, say 40,000 lbs. or 40 units of 1,000 lbs. each, the total tractive power unit miles consumed on the road would be 480,000,000. To maintain the power in par condition shops must in a year, turn out the same number of tractive power unit miles. The measure of their gain or loss over any period of time may readily be ascertained by balancing production and consumption. A formula for arriving at erecting shop capacity may be expressed in the following terms:

$$C = \frac{N \times D \times L}{\frac{MR}{MA} \times Y}$$

where

C—Total lineal engine erecting space.
N—Number of engines tributary to shop.
D—Calendar days in shop.
L—Average length of space allowed per locomotive.
MR—Average T. P. U. Mileage between repairs.
MA—Average T. P. U. Mileage per locomotive per annum.
Y—Days per year (365).

This applies to a longitudinal shop but the formula may be used for a transverse shop by eliminating L and considering C as the number of pits. Or it may be applied, to determine the number of positions, to the horse shoe type of shop, a design which has recently developed for progressive locomotive repairs, in a similar manner, but with this type the days in shop would be less. After arriving at the capacity of shops for normal maintenance as at present, a percentage should be added for growth in size and number of locomotives for a period within which it would be uneconomical to make shop extensions. This additional capacity also provides the means for reducing to normal basis, the capital mileage deficit at time of new shop installation.

No two roads have exactly the same conditions affecting the wear of equipment. It is therefore necessary to secure detailed information with regard to the distribution of the equipment, the grades and curvature of tracks, and the character of fuel and water used on various divisions. These, together with the general climatic conditions largely determine the rate of repairs for machinery and tires as well as boiler and firebox renewals to locomotives. Therefore, a careful study of these factors is required to properly proportion the departmental relationship of the locomotive repair shops.

In the case of the present road, it was found that as measured by engine standing space under cover, there was actually more than necessary under modern shopping methods. The real output capacity of a modern railroad repair shop is dependent upon proper machine tool equipment, crane service and the organization and method of handling equipment through the shops, more than the actual floor space occupied by standing equipment undergoing repairs.

For economy of floor space in housing these engines while under repairs, obviously the most economical type of shop was the longitudinal, and further, this arrangement was necessitated by the requirements of the site in conjunction with existing buildings which it was deemed inadvisable to destroy.

On the D. & R. G. W. as before mentioned, largely because of the diversity of equipment, the locomotive shop was so arranged that the service tracks run parallel with its length, but the routing of the locomotives is such within the shop that a progressive or semi-progressive handling results, which makes possible low unit repair costs in the various departments.

The shop is departmentized so far as it is feasible, machine tool groups for the various operations being placed immediately adjacent to the section of the erecting shop where such parts enter the assembly. Thus, the wheel department is at the extreme end of the shop adjacent to the unwheeling and wheeling pits, and immediately next is located the driving box department and so on. A balcony extending under the machine shop crane so as to be served by the same is provided for the brass department, head light, electrical and for other similar work. The boiler shop is located in the opposite end of the building from the wheel department but is so arranged as to be served by the erecting and machine shop cranes, thus minimizing the movement of boiler work. The result of the departmental relationship is such as to reduce the lost time in the handling of parts to and from engines undergoing repairs to a minimum, with a resulting economy in cost. The motive power materials coming mostly from the east, it was evident that a manufacturing department located in the Denver shop at the eastern terminus of the system would be an economical provision, parts produced here to be distributed over the system through the stores department, and this has proved a successful innovation. Because of the necessity of maintaining operation of the existing shops at both Denver and Salt Lake City, through the rehabilitation period, it was necessary to predetermine a schedule of operations, placing the various improvements in their proper sequence to secure a minimum of interference with the regular operation of the shop, and this was carried out as planned in an entirely successful manner, the finally rebuilt plants being completed, including the making of plans for same, within a year.

The detailed design of the new locomotive repair shops was of course complicated by the presence of the existing structures and numerous instances of adaptation of new work to these conditions occurred. At Denver the provision of new locomotive erecting, machine, and boiler shop released the old locomotive shop for use as a blacksmith shop, the old shop being razed together with a number of minor structures after the erection of the new shop. It also released a large section of the round house which was of concrete construction, provided with an overhead traveling crane used for an erecting shop, several stalls in the end however, being retained for tank shop where they could be served jointly with the boiler and machine shop by means of an outside yard crane.

Rehabilitation of power plant and distributing systems, shop heating and ventilation and other service systems were provided in a manner to correspond with shop requirements. Adaquate electric overhead cranes, local hoists, and modern machine tools in ample capacity and variety were provided, including some of the heavy production tools long used by manufacturers but not so generally by railroads—these reducing time of machine operations, with resulting economy.

Car Department Requirements

The requirements of the passenger car department were such, as determined by analysis, that no material increase in facilities were required, and therefore improvements in this department were nominal and confined to the changing of some features which increased the output of existing buildings such as new electrically operated transfer table at Denver shop. This, however, is utilized in connection with the new facilities for freight car repairs so it very economically serves a double purpose.

In approaching the problem of freight car repairs, a number of factors were taken into consideration, which in the past apparently have not been given full weight, the outstanding one being the relation of the total cost of freight car repairs to the cost of motive power repairs, in this case, the cost of freight car repairs being in excess of cost of locomotives repairs. A comparative analysis of many other roads in the country shows much the same relationship, in some instances, cost of freight car repairs being considerably in excess of cost of motive power repairs, and in others about equal to, or slightly less. The point is that for the past twenty or twenty-five years railroad officials have appreciated the necessity for modern machinery, crane service and well heated and ventilated buildings for the locomotive repair department and have well realized the economic advantage of providing such facilities. On the other hand, it seems to have been the current idea that all the car department required was a few rusty rails called rip tracks, some hand jacks, together with saws and hammers and a husky foreman. With the greatly increased rates of pay to car repairers, resulting in total cost of car repairs equal to that of locomotive repairs, it would appear entirely consistent to provide the car department with adequate facilities for economical repairs, such as modern machines, crane and hoist service, portable pneumatic and electric assembly tools, all properly installed within a comfortable building where men can do a normal day's work and do it in a frame of mind conducive to effective co-operation of the management.

For many years it has been my belief that the railroads have failed to take advantage of the large saving which could easily be accomplished in the conduct of car repairs, not only from the standpoint of reduction of man hours required, but the highly important advantage of reducing the days out of service to a fraction of what has been countenanced in the past. On the present road, in approaching the problem of freight car repair facilities and having made analysis of the factors contributing to the requirements for such, full weight was given to the advantage of providing repair shops of adequate facilities, rather than extending the rip tracks. Here again, the measure of shop capacity is not mere standing space, and the conception of the problem centered around an entirely new plan of operation, and now that the shops have been completed and in service for several months, they show a reduction of one-third in man hours. This is based on a recent statement of the receiver, Mr. Beason, that the original estimate of 25 per cent had been exceeded to this extent.

It is easily possible to increase the number of men per car from 1 or 1½ commonly employed under the old methods to 6 or 8 men, clearing the car for service in proportionately less time. Where the shops are relatively small as planned in the case of the D. & R. G. W., well distributed on the system, advantage can be taken of the old-fashioned esprit de corps, which has been lost in our modern large organizations. There is both economy and interest introduced in the layout of the shop where duplicate assembly lines are provided. First, in the ability to reduce shop capacity 50 per cent without in any way affecting the maximum economy of operation; and second, in the possibility of friendly competition between parallel gangs which adds considerable zest to the work.

The problem of transportation of materials, including supplies from the storehouse in connection with freight car repair department, is as highly important as that of the locomotive shops. Here are inevitably involved greater distances and interference of numerous tracks and in order to obtain maximum flexibility of transportation units the tractor and crane truck delivery system with well conditioned roadways is essential. In this instance, a regular delivery system was installed with a convenient receiving station in each department and suitable bins and racks located at each work station. In order to leave the main floor of the freight car repair shop as free as possible for the under structure work, a second floor or series of upper decks connected by conterbalanced bridges was installed, served by outside elevators, thus making possible deliveries direct to the work stations on the upper deck, all materials going into the superstructures, roofs, doors, running boards and other fixtures being handled conveniently from above. Here also the supplies are racked or binned immediately at hand for the specialized gangs.

The arrangement of the work in progressive movement from stripping to stenciling eliminates much interference from cross travel of both men and materials, and this together with organization of the men into specialist groups markedly reduces the opportunity for accidents.

Car repairs, even though the units are scheduled in advance in classified groups, necessarily involve an element of variability inherently adverse to station to station methods, as so successfully applied by manufacturing concerns, but by the provision of floating or balancing gangs of picked men chosen for their versatility on all classes of car repair work it is possible to measurably approach the results obtained by manufacturers. Scheduling of cars entering shops and ordering well in advance all materials required based on careful inspection is absolutely necessary to realize best results from this method of conducting car repairs.

An important phase of the design of locomotive and car repair plants and including engine terminals to a measurable extent is a carefully conceived stores department and delivery system. Millions of hours of skilled mechanics' time have been squandered in frequent trips from his work station to the store department for materials or tools, and this can be almost entirely saved by a comprehensive and adequate system of delivery from store house or yard to receiving station in various departments almost immediately at the hands of the workmen in such department. Modern trucks and tractors, either or both gas and electric of varied design suitable for application, are available and make possible the entire elimination of the old-fashioned industrial track and push car means of transportation still largely used in shop plants. Simple analysis of tonnages moved and man hours eliminated leads to immediate realization of the very considerable saving accomplished on a modest investment.

Standardization of both materials and tools greatly enhances the possible savings under a delivery system, and in connection with standardization attention should be drawn to the problem of handling the manufacturing for stores departments to the end of balancing the savings in quantity production cost against the carrying charges on stock, as this is the limit to which lot orders can be extended.

It will be noted that costs as related to the various factors of analysis have not been touched upon; this for the reason that costs always vary with local conditions and therefore mean little except in the light of these conditions. Cost factors are, of course, determined in every way possible and are utilized in any analysis as to design of facilities, but these, as well as practically all factors in the problem, must be applied with a broad background of experience to arrive at a practicable solution. With many variables and empirical assumptions to deal with, experience is the guide to results. In the present instance it can be said that while the improvement program was predicted upon an estimated investment return of 20 per cent, the receiver, Mr. Beacon, has recently stated that results are measurably better than estimated. This in part is, no doubt, due to the increased efficiency of the organization he has been successfully developing.

The extent of return upon investment is the final measure of accomplishment and any program undertaken should be based upon a sound relation between investment in equipment and in maintenance facilities, and always with adequate service assured.

The Zoelly Turbine-Driven Locomotive

An Experimental Locomotive in Use on the Swiss Federal Railways

In a paper to be presented at the annual meeting of the American Society of Mechanical Engineers in December, H. Zoelly describes a recently constructed experimental turbine locomotive, the object of whose design was to make some approach to the economical functioning of engines in stationary service.

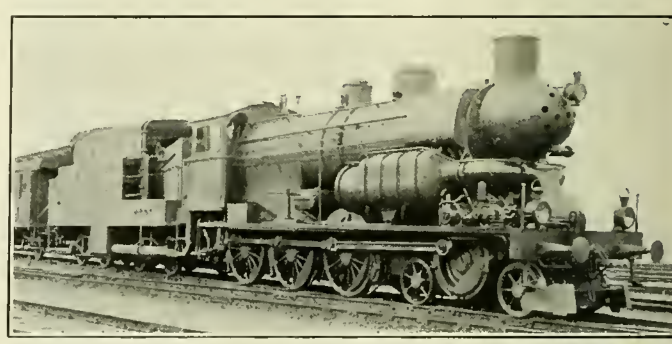
The experimental machine was constructed by changing a standard piston type locomotive belonging to the Swiss Federal Railways. Some of the data of the transformed locomotive was as follows:

Boiler pressure	200 lb.
Superheat	662 deg. fahr.
Heating surface of furnace	132.5 sq. ft.
Total heating surface	1060.0 sq. ft.
Surface of superheater	380.0 sq. ft.
Total heating surface inclusive of superheater	1450.0 sq. ft.
Grate surface	25 sq. ft.
Diameter of driving wheels	60 in.
Rigid wheelbase	6 ft.
Total wheelbase	25 ft.
Total wheelbase, including tender	58.4 ft.
Weight of locomotive, empty	60 tons
Weight in running order	65 tons
Adhesion weight	45.6 tons
Length over buffers, including tender	68 ft.
Extreme height	13.8 ft.

As will be seen from the engraving, the cylinders were removed and the turbine was placed on the extension of the frames in front of the smokebox. There are two of these turbines, one for running ahead and the other for backing. Their shafts are connected by reducing gearing to a jackshaft carrying a crank disc at each end whose center is in the same horizontal plane as the driving wheel centers. Reaching back from the pins on these discs is a connecting or section of side rod to the crankpin of the front driving wheel. Thence, backward the ordinary side rod is used.

No change was made in the boiler, which is provided with a Schmidt superheater, with the exception that a turbine driven fan has been placed in the front part of the smokebox, so as to provide the necessary draft for the fire.

The forward motion turbine is designed to produce 1,000 horsepower at the crankpin, and is a 6-stage impulse



The Zoelly Turbine-Driven Locomotive

machine. There are two reduction gears, the first is a 1 to 7 and the second a 1 to 4.1.

The turbine casing with reduction gear, intermediate shaft, jackshaft, and all bearings are mounted on a one-piece steel casing which is riveted to the locomotive frames. The turbine is placed in front of the boiler, its axis being parallel to the locomotive axles.

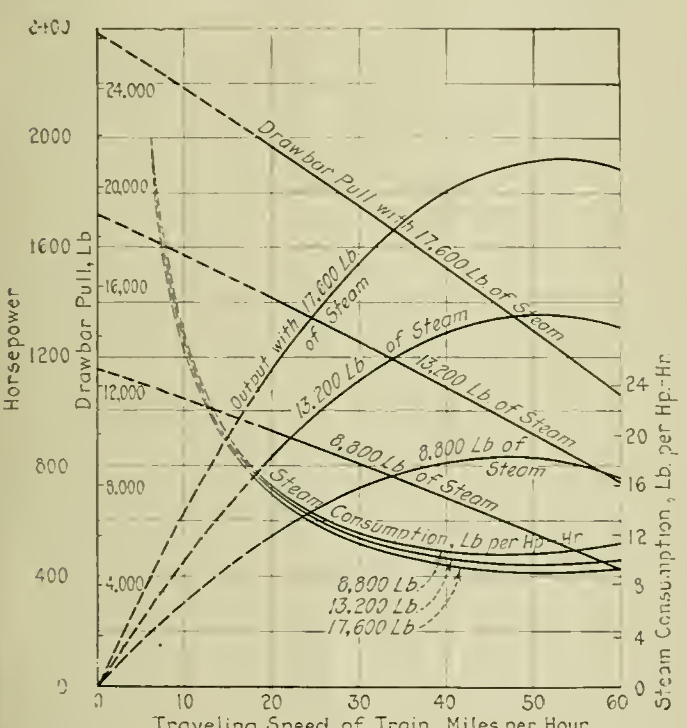
The maximum speed of the locomotive is placed at 47 miles per hour, which, as the drivers have a diameter of 60 in., means a rotating speed of the turbine of a little more than 7,500 revolutions per minute under these conditions.

Steam is admitted to the two turbines through what amounts to four throttle valves. There is the main throttle valve in the dome by which the flow of steam, as a whole, is controlled. The dry pipe from this valve leads to two other valves which are operated from the cab and by which steam in varying amounts may be admitted to the forward motion turbine; and also to a third, by which steam is admitted to the backing turbine.

In order to obtain the maximum efficiency from the turbine the exhaust steam is condensed, and this is the reason for the use of the fan for producing the furnace draft.

Two condensers are used and these are placed on either side of the boiler at the front end. These condensers are water cooled and of the surface type. The water used is drawn from the tender by the circulating pump, which forces it through the condensers and thence back again to the recooler which is placed upon the tender.

This recooler is the most vital part of the mechanism, and is arranged so that the cooling is effected by the



Output, Drawbar Pull, and Steam Consumption of 2000-Hp. Zoelly Turbo-Locomotive for Different Speeds and Steam Quantities

natural draft of air developed by the moving train and augmented by a fan.

It may be added that all of the auxiliaries of the condensing plant are driven by one small turbine.

No tests have yet been made as to the actual efficiency of the machine but very elaborate calculations have been made as to what it ought to be. According to these calculations there should be a steam saving of about 35 per cent per indicated horsepower per hour and a coal saving of about 46 per cent.

The accompanying diagram shows the calculated efficiencies of the engine at varying speeds and varying steam consumptions. This steam consumption is placed at 17,600 lbs., 13,200 lbs. and 8,800 lbs. per hour. For example at a speed of 30 miles per hour and a steam consumption of 17,600 lbs. there will be developed a drawbar pull of about 19,000 lbs., and about 1,550 horsepower and this on about 11.4 lbs. of steam per horsepower hour.

A second engine of the same general design has been built by the Krupps, but it has not yet been placed in service, while the experimental machine has been operated on short runs of about 35 miles.

Before starting the engineer speeds up the turbine driving the fan on the recooler, which operation consists solely in opening the corresponding valve. As this turbine is conected in series with the auxiliary turbine driving the condensing auxiliaries, the condensing plant is started automatically. After the working vacuum has been attained, which takes several minutes, the steam-admission valve to the main turbine is opened wide, and when it is desired to start the train it is only necessary to open the governor valve. On the experimental machine it is also necessary to have the furnace fan started, which, however, only requires a valve to be opened. The opening of this valve is governed in such a way that the boiler pressure is kept constant. Boiler feeding is no longer necessary. To keep the locomotive going at a certain speed it is no longer necessary to vary the degree of admission; all that is required is simply to throttle the steam admission to the required extent. If for any reason the output is insufficient with the governor valve wide open, then the overload valve allows an increase.

All that is required to stop the locomotive is to close the governor valve. The auxiliaries are not to be shut down unless for a prolonged stop.

To change over from running ahead to running backwards, after first having stopped the machine, the valve for running ahead is closed and that for running backward is opened; after which all that is necessary is to open the governing valve.

Starting up takes place very smoothly, and the fears expressed by many engineers that a turbine-driven locomotive would not have sufficient initial torque, are absolutely unfounded.

The running of the turbine-driven machine is also very smooth compared with that of a piston locomotive, this being on account of the absence of reciprocating masses. The drawbar pull also is constant, as is shown by the smooth line which is obtained in a diagram taken with a dynamometer.

To this must be added an absence of the excess vertical stresses caused by the counterbalance. Though even with a perfectly balanced locomotive this will persist, and reach a certain percentage above the static load just as it does on cars, where there is no counterbalance or unbalanced weights, but simply as a result of spring action and track inequalities.

New 4-10-2 Type Locomotive

A new design locomotive of the 4-10-2 wheel arrangement and the first of this type to be built in the United States, is now under construction for the Southern Pacific Railway by the American Locomotive Company.

The outstanding feature is the unusual wheel arrangement which might be considered as an evolution of the Mastodon or 4-10-0 type locomotive. In this new design a set of trailer wheels is included which gives the 4-10-2 wheel arrangement. It will be known as the Southern Pacific type.

The locomotive is of the three-cylinder type, and when completed it is claimed that it will be the largest and most powerful articulated locomotive in the world.

Some of the dimensions of this new design are: diameter and stroke of the two outside cylinders, 25 in. and 32 in.; diameter and stroke of the one inside cylinder, 25 and 28 in.; the total weight in working order, 438,000 lbs.; weight on drivers, 310 000 lbs.; diameter of driving wheels, 63½ in.; boiler steam pressure, 225 lbs.

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The Three-Cylinder Locomotive

That the theoretical advantages of the three-cylinder locomotive have been long recognized is evidenced by the fact that so many attempts have been made to put it into practical shape.

Probably the most widely advertised attempt to accomplish this was that of the three-cylinder compound designed by Mr. F. W. Webb, of the Northwestern of England, a number of years ago. That locomotive persisted so long as Mr. Webb was at the head of the mechanical department, but its shrift was indeed short after his regime came to an end.

One of the chief troubles in that case was the valve gearing, which was so arranged that the low and high pressure cylinders were, at times, attempting to move the locomotive in opposite directions.

This objection, at least, seems to have been entirely overcome in the case of the three-cylinder locomotives built by the American Locomotive Company for the South Manchurian Railway, and illustrated in another column. The ingenious and yet simple manner in which the valve of the central cylinder is driven by the stems of the two outside valves is deserving of close attention and examination. The actual combination of levers is not new. But while this may be true, there is a wide difference between a combination *per se*, and the making of such an adjustment of that combination that the results will be a satisfactory movement of the valves and valve events. A study of the tabulation published in connection with the description of the locomotive will show that this has been attained to a remarkable degree. When we take the three cylinders, for example, on a twenty per cent cut-off and find a maximum variation in that event to range from 5 in. to 6¼ in., and that the maximum variation between the front and back ends of any one cylinder is only ⅜ in., we are coming very close to the point of maximum attainable efficiency, especially when we find that the cut-off in the central cylinder is equalized.

Now, the London & Northeastern used this same general combination of levers; but it required that change of ratios of the arms of the long lever from 2 to 1 to 473 to 945, and instead of making the arms of the equalizing lever of the same length to give them the ratio of 217 to 219 to secure the results here attained. It was that final difference of 1/16 in. in the long lever and ⅛ in. in the short one that made the difference between a satisfactory and unsatisfactory adjustment. It was such a seemingly easy thing to do, but it is a safe assertion to make, that much time and study was spent on it before the final proportions were reached.

The same is true of the very ingenious arrangement of the steam passages in the right-hand cylinder and saddle casting which is shown in some detail. The securing of the flow of steam without abrupt bends and without checking the flow to and from any one cylinder, while maintaining a uniform thickness of metal in the casting is a skillful piece of work.

According to figures that are available there are at least six of these locomotives in service and at least sixteen on order, a part of the latter being a repeat from the Lehigh Valley, which received the first one of new construction, though not the first of this type put out by the company.

The reduction of vertical stresses, the increased starting power and shorter cut-offs made available are some of the advantages presented by the advocates of the design, and they all seem to be well taken. It now only remains to be seen as to whether time, wear and tear, maintenance charges and handling capacity will sustain the promises of the new design.

President Coolidge on Government Ownership

In the course of his address at a meeting of the United States Chamber of Commerce on October 23, President Coolidge discussed briefly the question of government ownership as follows:

"It has always been the theory of our institutions," he said, "that the people should own the government and not that the government should own the people. James Otis stated this principle before the Revolution, when he said that 'kings were made for the people, and not the people for them.' This policy cannot be maintained unless the people continue to own and control their own property. The most important property of the country is transportation, and water power. It is not only very large in amount, but is of the greatest strategic value. It could be used in such a way as to assume virtual control of all other business of any importance. It is proposed that these properties should be brought under public ownership. Responsible public commissions have valued these at about $35,000,000,000. Such a cost would more than double all our public debts. Any deficit in earnings would have to be made up out of taxes. We did that during the war at a cost of $1,600,000,000. With the government in possession of such a great engine, with two and three-quarters millions of employees, spending $9,000,000,000 or $10,000,000,000 each year, holding virtually the power of life and death, what chance would the rest of the people of this country have? It would appear to be perfectly obvious that if these properties are taken off the tax list by public ownership, the other property of the nation must pay their yearly tax of some $600,000,000. In the thinly settled agricultural regions this would make an increase of 30 or 40 per cent on local taxation.

"They have government ownership abroad. It takes 23 men in Germany to move a ton of freight one mile, 24 men in Italy, 31 in Switzerland. In the United States it takes only 5 men. It is interesting to note also that reduced to terms of bread and butter, railroad employees in these countries show weekly earnings of only about one-third of those in this country. Measured by our experience, by efficiency of service, by rate of wages paid, we have everything to lose and nothing to gain by public ownership. It would be a most perilous undertaking, both to the welfare of business and the independence of the people."

An Analysis of Grade Crossing Accidents

For four months the Pennsylvania Railroad kept a careful report of all grade crossing accidents along its lines, and obtained the following data:

There were 682 crossing accidents resulting in 90 fatalities and 150 injuries. Of these 682 accidents, 487 occurred in broad daylight and 195 at night, from which an inference may be drawn that an inability to see the railroad in the distance is not as much a factor as the failure of auto drivers to be careful.

Approximately 60 per cent of the trains involved were runnig less than 20 miles per hour, indicating that the failure of auto drivers to keep a constant lookout ahead and to have their cars under control is a greater factor in crossing accidents than the speed of the trains.

Seven fatalities and 17 injuries were due to drivers of automobiles attempting to beat trains running at various speeds over the crossings.

Fourteen fatalities and 7 injuries occurred at crossings protected with crossing bells which were in good order and ringing at the time of the accidents.

Sixteen accidents were attributable to defective brakes although it is probable that this was the indirect cause, as it is impossible to ascertain the condition of the brakes when automobiles are demolished.

As a sidelight on this factor of defective brakes, it may be stated that during January, 1923, the Police Department of New York City inspected 4,000 cars and found 800 with defective brakes and of these 800, 142 had inoperative brakes and the drivers were arrested.

There were 280 cases of automobiles running through or into crossing gates, but not into trains.

In a period of four months on the Pennsylvania System, 70 instances were recorded of automobiles running into the side of trains. These 70 accidents resulted in 14 deaths and 22 injuries. In many instances the automobile came in contact with the train some time after the head of the train had passed over the crossing.

A case is reported on another road of an automobile running into the caboose of a long freight train.

The Great Northern Railroad at the present time is suing the owner of a "flivver" for running into the observation platform on the rear end of its "Oriental Ltd." while that train was standing still.

South Manchurian Railway

In connection with the three-cylinder locomotive illustrated and described in another column the following data regarding the railway upon which it is to run is of interest.

In 1905 the Peace Treaty between Russia and Japan was signed at Portsmouth. By this Treaty the southern portions of a great railway running through Manchuria from Changchun southward to the port of Dairen, and originally the property of Russia, was transferred to Japan. In 1906, by Imperial ordinance, the South Manchuria Railway Company was founded and the railway properties were taken over.

Originally built by the Russians, cheaply constructed, and poorly equipped, it was of strategic military value, but absolutely inadequate for the commercial development of a growing country. The South Manchurian Railway immediately began a comprehensive program of reconstruction.

Heavy rails, locomotives, freight and passenger cars were brought from the United States, the lines were rebuilt and double tracked, and a standard American railway was constructed in place of the old Russian line.

The equipment consists of 340 locomotives, 5,624 freight cars, including 2,224 box cars, 2,374 flat cars, and a full equipment of coal, ore, sand, tank, refrigerator and caboose cars; 328 passenger cars, including compartment Pullmans and American dining cars.

The car and locomotive shops at Shakakou, near Dairen, are among the largest and best equipped in the Orient, having a capacity of simultaneously repairing 27 locomotives, 36 passenger and 130 freight cars.

The principal activities of the South Manchurian Railway Company are as follows:

The Company owns and operates 686 miles of railway lines in South Manchuria, and also operates the Chosen State Railways with a mileage of 1153.

Docks, wharves, and warehouses at Dairen, Yinghou, Antung and Shanghai. Dairen has been made the best equipped harbor in the Far East with a capacity for docking at one time 50 vessels of 85,000 tons.

Bituminous mines at Fushun and Yentai, equipped with modern American equipment, and with a reserve of 1,200,000,000 tons.

A modern steel plant at Anshan, with an ultimate annual capacity of 1,000,000 tons of steel, utilizing the ore of the Anshan mines whose reserves are estimated at several hundred million tons.

Electric light and power plants at Dairen, Antung, Fushun, Mukden, and Changchun, and electric street railways in Dairen, and Fushun, the total annual output reaching 20,000,000 kilowatts. A large gas plant at Dairen, with a production of 215,000,000 cubic feet a year, and a smaller plant at Anshan.

A chain of modern hotels along the line of the railway, including Dairen, Port Arthur, Mukden, Changchun, and the seaside resorts, Hoshigaura and Ogandai.

A central laboratory in Darien charged with the study of the utilization of agricultural and other products, and public health problems. A geological institute in Darien making mineral and soil surveys and analyses. Agricultural experiment stations operated at Kungchuling and Hsiungyocheng, and 16 nurseries, and experimental farms at Telissu and Chengchiatan.

Under the direction of the Japanese Government the railway also undertakes town planning, organizes sanitation, conducts schools and hospitals, and lends its aid to civic betterment work.

The number of employees is estimated at 37,500.

Medal Awarded in Recognition of Locomotive Feedwater Heater

At a meeting of the Franklin Institute, at Philadelphia, Pa., October 15, two medals were awarded in recognition of recent inventive achievements. The Edward Longstreth medal was presented to Thomas C. McBride for his development of the locomotive feedwater heater. The Edward Longstreth medal was also awarded to Milton Roy Sheen in recognition of his development of the Sheen tunneler.

Valve Gears for Three Cylinder Engines

THE EDITOR:

Permit me to offer a few words of explanation in connection with Mr. W. G. Landon's article on page 316 of your October issue.

Mr. Landon has not stated the real reason for the application of three separate sets of valve-gearing to the new Class P-46-17 (formerly Prussian-Hessian Class P-10) locomotives of the German State Railways. There are in Germany to-day some 125 three-cylinder superheated 4-6-0 passenger locomotives of Class S-35-17 (formerly Prussian-Hessian Class S-10²), which have the arrangement of valve-gear shown in Figure 2 of Mr. Landon's article. (For convenience in reference, the cut is here reproduced.—Eds.) There are also 85 three-cylinder 2-8-0 engines of Class G-45-17 (formerly Prussian-Hessian Class G-83), and about 1,600 three-cylinder 2-10-0 locomotives of Class G-56-15 (formerly Prussian-Hessian Class G-12). The valve-gear for the central cylinder of these latter two classes of locomotives is a combination of vertical levers, unlike any shown in Mr. Landon's article, but identical in principle with Fig. 3 on page 316.

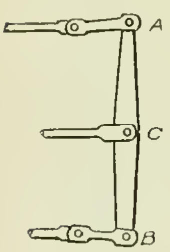


FIG 1.

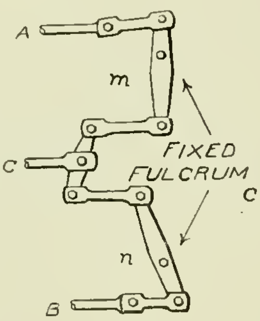


FIG. 2.

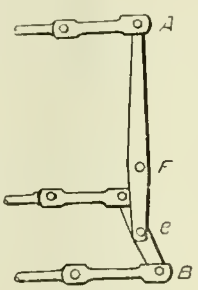


FIG. 3.

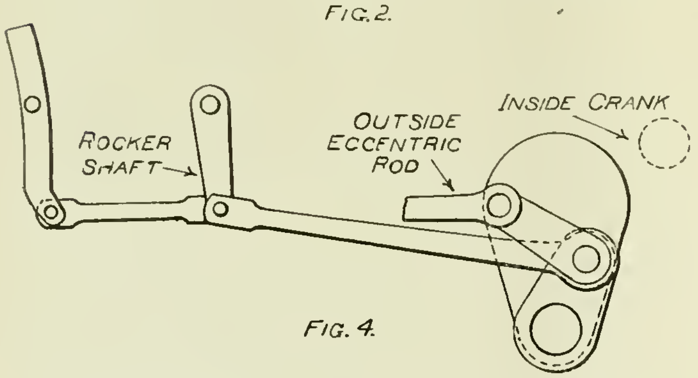


FIG. 4.

Designs of Valve Gears for Operating Three-Cylinder Engines

After an experience with this large number of approximately 1,800 three-cylinder engines dating back to 1914, and after numerous tests and experiments, the conclusion was reached that the derivation of the movement of the central valve from a combination of the motions of the two outside valves, is entirely unsatisfactory, for the reason that whenever the cut-off in the outside cylinders is shortened beyond a certain point, and the speed is increased above a moderate valve, the cut-off and consequently the mean effective pressure and horsepower developed in the central cylinder are much greater than in either of the outside cylinders. Under these conditions, the superior torque, and "even" turning-moment of the three-cylinder locomotive become largely imaginary. In the G-12 Class 2-10-0 engines, it was found that when running at 15% cut-off and at a speed of 33 m. p. h., the power developed in the central cylinder was 56% greater than in either of the outside cylinders. Practically the same results were obtained from the 4-6-0 engines. In this connection, it should be remembered that it is customary in Europe to operate simple engines at somewhat shorter cylinder cut-offs than are usual in America, thus aggravating the defects which are inherent in these types of combination valve-gears.

If you will refer to the indicator cards from the Lehigh Valley R.R. engine No. 5,000, which are reproduced in a recent pamphlet by the American Locomotive Company, you will note that the same trouble found in Germany, is also present in this engine when running at a cut-off of about 20%, the central cylinder develops 45% more horsepower than either of the outside cylinders. The type of gear used on the Lehigh Valley locomotive would therefore appear to be unsuitable for passenger locomotives, at least.

Apparently the gear shown in Mr. Landon's Fig. 3 has given satisfaction on the former Great Northern Ry. of England, but there is evidence that the same arrangement has not given the results anticipated on the former Caledonian Ry., as one of their large 4-6-0 engines has been fitted with an independent set of valve motion for the central cylinder. The former North Eastern Ry., which has used the three-cylinder type for 15 years, has always adhered to the use of separate gearing for each cylinder.

The foregoing facts will explain why, in 1922, when the designs for the German 2-8-2 passenger locomotives, Class P-46-17, were being prepared, Messrs. Borsig were instructed to use the valve motion depicted in Fig. 4 of Mr. Landon's article on page 316 of your October issue.

Galveston, Texas. Wm. T. Hoecker.

Hungarian Railway Situation

If the advocates of government ownership of the railways were to take cognizance of all the news of the world on the subject and the results obtained as a result of such an ownership, their advocacy would probably die a natural death. Take this from Hungary as an example:

The total mileage of the Hungarian railway system is 8,724 kilometers, of which 83.9 per cent are under the management of the Hungarian State Railways, 6.9 per cent under the management of the Danube-Save-Adriatic Railway, and the remaining 9.2 per cent is operated by 11 private companies. During 1923, the railroads carried 73,855,094 passengers and 23,823,002 metric tons of freight. The employees numbered 73,806, of whom 68,425 are in the employ of the State Railways.

The State Railways during the fiscal year ended June 30, 1923, operated with a deficit of 20,000,000,000 paper crowns. During the first half of the year 1923-24, the deficit amounted to 85,000,000,000 paper crowns and the railway is therefore experiencing a serious crisis. This deficit is due to the abnormally large number of persons on the pay roll and pension lists, the payments to these persons amounting to about 66 per cent of the receipts of the roads. The receipts of the lines are likewise greatly reduced by the large number of state employes and others who enjoy special privileges in the shape of reduced fares on the state railways. Nearly two-thirds of the passengers carried, it is estimated, fail to pay the full fare, and since the reductions range from 66 per cent to 90 per cent, the loss of income to the railroads from this source is very great.

To partially cover deficits, the State Railways negotiated a loan of 31,000,000,000 paper crowns, which was granted by the association of bankers, but this amount did not suffice to meet the deficit of 70,000,000,000 created by losses in foreign exchange growing out of the railroads' business with foreign railroad companies.

Motor-Generator Type Locomotives for Detroit & Ironton Electrification

By FRED ALLISON and H. L. MAHER, Ford Motor Company, and L. J. HIBBARD, Westinghouse Electric & Manufacturing Co.

A most important development in the electrification of steam railroads is that recently announced for the Detroit & Ironton Railroad Company. Not only does this development mark another step of progress in the use of electrical energy as a motive power, but it forms another practical demonstration of the inherent flexibility of the alternating current system for railroad electrification.

As usual, Mr. Ford has not been restricted by past practice or tendencies in the choice of electrical system and of type of motive power units for his road.

The result has been the adoption of a trolley voltage of 22,000 volts, 25 cycles, alternating current, a trolley voltage twice as high as any previously used in this country. Also a type of motive power unit that is not only novel in electrical design, but embodies many new and important ideas in the mechanical design, has been adopted for this installation.

The mechanical parts for the new locomotives are being designed and built by the Ford Motor Company while the electrical equipment is being designed and built to F. M. Co. specifications by the Westinghouse Electric & Manufacturing Company. The initial order calls for a locomotive comprising two motive power units operated in multiple.

Locomotive Rating

The locomotive will develop a maximum of 5,000 hp. at 17 mph. and will exert a maximum starting tractive effort of 225,000 lbs. on the basis of a 42,500 lb. axle loading with 33⅓ per cent adhesion. The nominal rating of the locomotive will be 4,200 hp. It will also deliver 3,600 hp. continually at all speeds between 17 mph. and 25 mph. and will exert 54,000 lb. T. E. continuously when operating at 25 mph.

Each motive power unit will be arranged for double-end operation so that an operating locomotive may consist of either one, two or more units as desired.

It is estimated that each motive power unit will weigh 170 tons. All weight will be carried on the driving wheels.

Type of Locomotive

The motive power unit selected for this electrification is of the motor-generator type.

The principal reasons which have led to the adoption of this type can be summarized as follows:

(1) Use of alternating current power supply for the trolley.

(2) Direct current traction motors of the most rugged type due to the opportunity to design the motor for its own best condition, regardless of voltages, line surges, etc. In other words the motors have the most rugged electrical characteristics and maximum space and weight efficiency that can be secured.

(3) Possibilities for the simplification of the mechanical parts due to the high space and weight efficiency obtained in the traction motors.

(4) Simplicity and flexibility of control.

(5) Simplicity of regenerative system and ability to regenerate at any speed from the maximum to practically standstill.

(6) Voltage control with consequent freedom from rheostatic losses, low accelerating, peak loads, and ability to operate continuously at any desired speed.

(7) Speed characteristics and ability of locomotive to adapt itself to all changes in the profile.

(8) Constant horsepower characteristic enabling the locomotive to develop its full capacity under a variety of speed and tractive effort conditions.

(9) Inherent voltage regulating effect of driving motor of locomotive motor-generator set with its attendant favorable effect on the distribution system.

(10) Little tendency for driver wheels to start or continue slipping during accelerating periods because the voltage impressed across each traction motor, while the maximum starting tractive effort is being exerted, is low and does not increase if slipping starts.

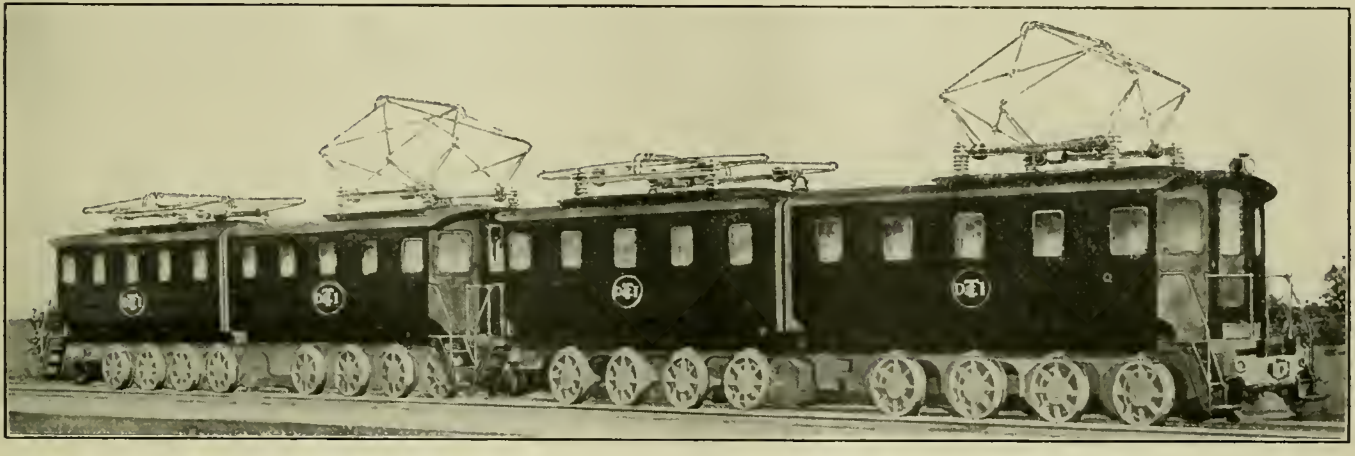
(11) Ability to maintain the a-c. power drawn by the locomotive at unity power factor and consequent tendency to low transmission losses.

(12) Ability to operate at full load in the same train with any other type of alternating current locomotive.

(13) Ability to operate as a constant speed type of locomotive on all applications where this feature is desirable by separately exciting the traction motors throughout the motoring period.

(14) Large number of constant running speeds obtainable when motoring on separately excited connections.

(15) Adaptability to locomotive designs with all weight on drivers.



How One of the Detroit & Ironton Railroad Electric Locomotives Will Look When Completed

In short this type of engine was adopted because it is believed that it will furnish a most flexible and reliable means of utilizing the power which will be delivered to it by the flexible high voltage alternating current trolley system.

Locomotive Equipment

Each motive power unit will be equipped with a transformer, a direct-current generator driven by a single-phase motor, eight axle-hung direct-current, series type traction motors, and suitable control and auxiliary apparatus. Single-phase alternating-current power at 22,000 volts will be collected from the overhead system by means of a pantagraph and conducted through an oil circuit-breaker to the primary side of the transformer, where it will be stepped down to a suitable voltage for driving the motor-generator set. Direct-current power, which can be regulated from zero to 600 volts, will be delivered by the motor-generator set to the traction motors, connected permanently in parallel.

The locomotive is designed for regenerative braking.

The locomotive transformer will be 2,000 Kva., two-circuit, oil-insulated, air-cooled railway type unit. The primary winding may be connected to receive either 22,000 or 11,000 volt power. The secondary will deliver current at 1,250 volts.

The high voltage side of the transformer will be connected between the circuit-breaker and ground to series with two single-pole, double-throw knife switches in such a way that the transformer can be connected to operate on either 22,000 or 11,000 volts as desired by throwing the switches to the proper position. This feature has been included so that these locomotives can be operated over connecting 11,000 volt lines if desired at some future date.

Motor Generator Set

The locomotive motor-generator set will consist of a 2,100 hp., 25-cycle, four-pole, single-phase motor, driving a 1,500-Kw. 600-volt, 2,500-ampere generator at 750 r.p.m. The set will be a self-contained machine supported at three points and will comprise two bearing brackets with suitable bearings, motor stator, a generator field, and a shaft carrying the generator armature and the motor rotor. A 75-Kw. 125-volts, direct-current "main exciter" will be mounted directly upon a shaft extension at the motor end of the set, while a 25-Kw. direct-current "regenerative exciter" will be mounted directly upon a shaft extension at the other end.

The generator will be provided with series excited differential field, interpole field and compensating field as well as a separately excited field. The 75-Kw. exciter will be used to supply excitation to the motor field, the generator field, regenerative exciter field, and to supply power for all auxiliary motors, and for the control circuits. The 25-Kw. regenerative exciter will be used to separately excite the traction motor fields during the regenerative period and during the high speed motoring periods.

The locomotive traction motors will be 225 hp., 600-volt, direct-current series, axle-hung machines. Each motor will be flexibly connected to the driving axle by double gearing, that is a gear at each side. A 22-tooth, 3½-in. face, 3 DP, pinion, suitable for meshing with a corresponding 98-tooth gear will be mounted on a shaft extension at each end of the motor. The motors will be of a special mechanical construction for application to the mechanical parts being designed and built by Mr. Ford.

Speed Control

Each motive power unit will be equipped with double-end control. Forty-five normal running speeds will be available between standstill and maximum speed during both the motoring and regenerating periods. The locomotive speed during both the motoring and regenerating periods will be manually controlled from standstill to seventeen miles per hour by regulating the main generator voltage and from 17 m.p.h. to the maximum speed by regulating the main field strength of the raction motors.

The traction motors will be connected as series excited motors during the motoring period from standstill to seventeen m.p.h. and as separately excited motors during the motoring period from 17 m.p.h. to maximum speed. The traction motor fields are separately excited throughout the entire regenerative period.

Regeneration may be obtained at any time while the traction motors are separately excited by regulating the generator voltage and traction motor field strength so that the motor voltage overbalances the generator voltage and causes the armature current to reverse. This will cause the traction motors to act as generators, driving the main generator as a motor which in turn drives the a-c. motor, causing it to become a generator and return power to the line.

A closed circuit type of transition will be utilized in going from the series excited to the separately excited connections of the traction motors and when desired the same type of transition may be used to change back to the series excited from the separately excited connections. Thus the separately excited connections may be completed while the traction motors are energized and working at full load, as series excited motors, without interrupting or appreciably changing the value of motoring tractive effort running speed of approximately seventeen miles per separately excited connections have been completed.

The closed circuit transitions can be utilized very advantageously during the motoring period to change from the series connections to the traction motor fields to the separately excited connection when it is desired to increase the speed of the locomotive by weakening the field strength of the traction motors. It can also be used to complete the separately excited connections as the locomotive is motoring up to and going over the top of a grade so that the engine will automatically start to regenerate as the speed of the train begins to increase on the down grade.

Typical Cycle of Operation

Starting from rest with a full tonnage train the traction motors will be energized as series excited motors and the train may be accelerated up to a continuous full tractive effort running speed of approximately seventeen miles per hour by manually regulating the main generator voltage by means of the external field resistor and a set of 50-ampere, 125-volt switches.

If desired and the load and grade conditions are such as to permit the use of a higher running speed than is obtainable with the series connections, a closed circuit transition will be made from the series connection to the separately excited connection of the traction motors. The speed may then be increased by weakening the field strength of the traction motors. This will be accomplished by manually regulating the regenerative exciter voltage through an external field resistor and a set of 5-ampere 125-volt switches. Then when the train passes over the crest of a hill and it is desired to maintain some constant speed while descending the grade, the traction motors will be made to act as generators by strengthening and properly regulating their fields. When the train is to be brought to rest heavier regenerative braking may be utilized if desired in bringing the train to a very low speed before applying the air brake. The speed may be decreased to approximately seventeen miles per hour by properly regulating the traction motor field strength while the speed may be decreased below seventeen miles per hour by regulating the generator voltage.

Lubrication and its Effect on Locomotive Service

A Report Presented at the Annual Convention of the Traveling Engineers' Association

The principle of lubrication is as old as man; and as he had to use but little ingenuity in discovering this principle and its purpose, it being exemplified in the articulation of his own frame, it is fair to assume that he acquired this knowledge at a very early period.

It is well known that the ancients possessed at least some simple types of machines, for the reason that they raised many great stones to a considerable height in completed works, after having transported them great distances from the quarries whence they were taken. And it cannot be doubted that engineers in building some of the great pyramids 4,000 years B. C. required the rubbing surfaces of the machines and implements in use to be lubricated, so as to be used more effectively. Neither can it be doubted that even at that early date the efficiency of various lubricants was discussed. Although some knowledge of this, one of the most important essentials to mechanical progress, has been possessed by man for many years, the subject has not been given the attention by the engineer and man of science that its importance would justify. However, science and mechanics are greatly indebted to some earnest and very able students of the subject for considerable practical information and working data, some of which has taken the form of world-wide formulæ.

The efficiency of a machine is measured by the quantity of work obtained, by dividing the amount of useful work performed by the gross work of the machine; and experience has taught that friction is the principal cause of loss of energy and waste of work in machinery. Also, that waste energy is reduced to a minimum by a proper choice of rubbing surfaces and by the best lubrication.

Since lubrication has for its object both the reduction of friction and the prevention of excessive development of heat, the value of the lubricant depends on its efficiency in reducing friction, its durability under wear, its freedom from liability to "gum," its freedom from acid and grit and its permanence of composition and its physical condition when subject to changes of temperature. It is of great importance to remember that the higher the temperature the less is the lubricating power of any lubricant; and consequently if we have an efficient lubricant under normal conditions, it should not be assumed that a hot bearing may be cooled by increasing the quantity of lubricants on it, but the cause of the bearing heating should be removed, and time and money saved.

It is needless for the writer to attempt any discussion or comparison of the various lubricants and their characteristics, which some chemists consider of so great importance in the selection of the lubricants. Suffice it to say, that it has long since been an acknowledged fact that vegetable oil and animal fats are inferior to properly refined petroleum oil for machinery lubrication. Nearly all vegetable and animal oils are compounds of glycerine with fatty acids, and in this respect essentially differ from the mineral oils. When kept for a long period decomposition takes place, acid is set free, and the oil becomes rancid. This rancid oil will attack and injure machinery.

Regarding viscosity, gravity and the flash, and burning temperature, assumed by some to be of so much value in determining the quality of lubricating oil, a prominent writer in his book on "Lubricants, Oils and Greases," says: "The tests that usually influence the choice or purchase of lubricating oils are the specific gravity and viscosity; but in reality these tests count for little, for the reason that but a small idea of the lubricating quality of an oil can be gained from either of the tests separately, and not very much even when taken conjointly, except in extreme cases; as, for instance, we know that a very thin light oil is useless for steam cylinder and heavy journal lubrication, and that a thick heavy oil is equally useless for light, high-speed spindles."

Another writer says of "specific gravity": "It may be pointed out that this characteristic affords little or no information as regards the lubricating powers of an oil. The specific gravity is, however, an aid in selecting an oil for a particular class of machinery. The viscosity does not furnish an absolute means of determining the lubricating value of an oil, either, although it enables one to draw certain conclusions. Thus, if the viscosity is too low, the film of oil which keeps the bearings of rapidly moving machinery apart is not sufficiently developed to keep the metal surfaces asunder, and therefore the friction between them is not sufficiently diminished. Again, if the viscosity of an oil is too high, the resistance of the film is so great that heating occurs and the bearings become warm, and even hot, the heat so generated being proportional to the internal friction of the oil, or, in other words, to its viscosity. That oil will prove the best which under given conditions of speed, pressure and temperature has the lowest permissible viscosity."

Many consumers of large quantities of lubricating oil, particularly large railway systems, are provided with laboratory facilities, both chemical and physical, and it not infrequently happens that those in charge of these laboratories feel that the department is not entirely fulfilling its purpose if it does not exercise a certain supervision over the purchase of lubricating oils; making very rigid requirements for the flash, burning, viscosity and gravity tests, assuming when the oils meet these requirements that they have fine lubricating qualities, when, as a matter of fact, oils having much better lubricating qualities may be barred by the very requirements intended to serve as a means for getting the best, the requirements thus defeating the very purpose they were intended to serve. Prof. Thurston in his book on "Friction and Lost Work in Machinery," states in this connection: "The consumer will usually find it economical to use that lubricant which he has found to be the best, with little regard to price, and often finds real economy in using the better material, gaining enough to pay excess in the total cost very many times over."

When it is considered that the locomotive, and all it has accomplished in the interests of man, would not have been possible but for the principle of lubrication, the importance of the knowledge of this subject becomes at once apparent. Lubrication has been, and is, just as essential in making the locomotive possible as that great source of power, heat energy, or the water which affords a medium for its conversion into an active force. Without lubrication the locomotive would be impossible, and even with it a considerable portion of the power developed by the locomotive is exerted to overcome the resistance in its moving parts due to friction.

While the information obtainable on the subject is rather meager, we know that the lubricants used and the means of applying them to the primitive locomotive were in keeping with the crude design of all the parts; and inasmuch as we find that the modern locomotive with its nicely designed parts and using the very best lubricant applied by modern methods, loses through friction over 10 per cent of the maximum power developed; and as we know this quantity or proportion of waste energy is considerably affected by the quality of the lubricant used, it is reasonable to suppose that the success of the early locomotive was in no small measure delayed by faulty and inefficient lubrication.

The present hydrostatic lubricator with its disc sight glasses and attachments for stopping the feed without disturbing the adjustment of the feed valve, and automatic drain valve for preventing loss of oil when draining lubricator, is a tremendous advance in the interest of safety and economy over the tallow cup of forty years ago. But it is neither fool-proof nor perfect; it requires intelligent handling for effective service, and for it to give the most effective service the locomotive must also have intelligent handling. The lubricator should be so located that the engineer may have an unobstructed view, not only of, but through the sight feed glasses; and in all cases it must be located so that the oil pipes have a constant downward course, as an upward turn in the pipe will pocket the oil and result in an intermittent feed to the valve and cylinder, and consequent imperfect lubrication.

The best service from a valve or cylinder oil requires that it enter the steam chest thoroughly atomized, each drop being divided into thousands of minute drops or atoms as it reaches the rubbing surfaces. This is accomplished by a combination process of emulsification, vaporization and atomization and it follows that a first-class cylinder oil must possess the qualities to readily emulsify and atomize, with a sufficient degree of vaporization to spread itself over the surface with the steam, in other words, to lubricate the steam. Uniformity of distribution is as important as the uniformity of supply. These are principles that apply to valve and cylinder lubrication, irrespective of type of valve or temperature of steam.

The design of valve and method of introducing the oil are very important factors. It has been practically demonstrated that a flat or slide valve cannot be successfully used with very high temperature of steam, because of the heat warping the valve, presenting an uneven surface to the heat, but with the modern locomotive of today we have piston valves with superheated steam which, after giving our engineers some alarm on the start, we find are as easy (if not easier) to lubricate than slide valves with saturated steam.

The evolution of the locomotive has carried with it the progress from the earlier method of delivering the lubricant through the medium of a plug cup, located on top of the steam chest, to the more convenient location in the cab. The automatic displacement cup located on top of the steam chest, has been superseded by the hydrostatic or mechanically operated lubricators, but it seems that because in the infancy of the locomotive from the top of the steam chest was the logical place to admit the lubricant, precedent rules that the old custom shall prevail.

Is there any good reason for a continuance of this practice, other than convenience, custom or precedent?

This line of argument does not apply to engines using superheated steam so much, as the heat at high temperature superheated steam is usually sufficient to separate the oil into particles small enough to be carried by the steam without the presence of water.

In connection with the thought just advanced it is proper to bear in mind that with the use of the hydrostatic lubricator, the oil is not forced into the steam chest, but is entirely dependent upon the force of gravity to carry it there. This depends upon gravity for perfect operation and the fact that the gravitative force only acts upon the oil when the steam pressure is uniform throughout the entire lgenth of the lubricator pipes, is probably the greatest imperfection of the hydrostatic lubricator; but its reliability in other respects and its ease of maintenance so preponderates this fault that it is commended as the most acceptable device for the purpose. As practically every handbook published for the benefit of the locomotive engineer describes in detail the various types of hydrostatic lubricators and the proper method of applying and operating them, it is not necessary to devote space to features that have been fully covered by more able writers.

The engineer of experience has learned that it is necessary when working his engine under certain conditions with full throttle to occasionally ease up on the throttle to permit the steam pressure in the lubricator pipe to equalize, otherwise the pressure becomes greatest at the steam chest end of the pipes, and the material in the pipes ceases to flow downward, thus interfering with proper lubrication. When the engineer is unacquainted with the existence of this condition, he often wrongly assumes that the lubricator is not feeding enough oil when his engine begins to indicate improper lubrication.

With the more general application of high temperature superheaters to locomotives many were concerned to know how the valves and cylinders of the locomotive using high temperature superheated steam were to be lubricated, and whether the oil would stand the high temperature and still retain its lubricating properties. Because of the use of improper material in the cylinders and packing, and the lack of experience in handling the superheat locomotives, much trouble was at first experienced in the operation and maintenance of some of these locomotives, and it was very promptly assumed by some that the fault lay in the lubricant. The manufacturers of the lubricant, after careful investigation, determined that the lubricant was able to meet this new tax upon it without being appreciably affected as to its value, and were very shortly able to convince the doubtful of the correctness of their conclusions.

Since the substitution of materials more able to resist wear and tear at high temperature, and a better knowledge resulting from experience in the proper handling of superheat locomotives, the troubles of maintenance and operation have practically disappeared and it has been found that this type of locomotive can be just as effectively and economically lubricated as the non-superheat locomotive.

The important thing to remember in the operation of the locomotive using superheated steam is that the lubricant does not flash or burn in an atmosphere of steam, even though it be 1,000 degrees Fahr.; therefore if care be exercised to maintain an atmosphere of steam in the steam chests and cylinders there will be no carbonization of a proper lubricant. Those railway officers having had the longest and most extensive experience in operating the superheat locomotives require these engines to be equipped with some form of auxiliary or drifting throttle to be opened when the main throttle is closed while the engine is drifting.

Experience has taught the unprejudiced that the direct cylinder feed is not only unnecessary, but that better results are actually obtained without it. Much of the accumulation in the cylinders and deposit on the cylinder walls of these engines is undoubtedly due to too much oil, and this has been found to be the case mostly with engines equipped with the lubricator pipes connected direct to the cylinders.

If the theory of effective valve and cylinder lubrication by saturating the live steam with the lubricants be true, then it is true that the lubricator pipes leading directly to the cylinders are not necessary, because ample lubrication is secured from the particles of oil contained in the steam, which must come in contact with the cylinder walls after leaving the steam chest. The hydrostatic lubricator must inevitably maintain a more continuous and uniform feed of oil to the cylinders on locomotives using superheated steam than on those using saturated steam; for the reason that the steam in being forced through the contorted passages of the superheater suffers a loss in pressure before reaching the steam chest, consequently the steam pressure in the lubricated pipes, at the steam chest end of the pipe, never exceeds or even equals the pressure of the lubricator end.

It should be borne in mind that the only force behind the steam flowing through the superheater to the steam chest is the boiler pressure, and that notwithstanding the superheating the steam in overcoming the friction in the superheater pipes must lose in pressure before reaching the steam chest.

The advancement in the lubrication of the external parts of the locomotive has probably not been so great as with valves and cylinders, yet a marked improvement has been effected, both in the interest of efficiency and economy, by the substitution of mineral for vegetable and animal oils for this purpose.

The introduction of mineral oil for locomotive lubrication can best be told by quoting from the 1909 report of the Master Mechanics Committee on Locomotive Lubrication. On page 269 of 1909 proceedings, American Railway Master Mechanics' Association, we find the following:

"The mineral oils or petroleums were placed on the market in the years soon following, and on account of their cheapness and superiority as a lubricant their use became general. The natural West Virginia oil, with its notable characteristics . . . immediately found favor and was considered superior to sperm. The production of West Virginia oil was limited, and as the demands rapidly increased the supply was soon exhausted. Mineral oils of varying qualities—good, indifferent and bad—competed for the lubricating business, and as uniformity was desirable the old adage of 'necessity being the mother of invention' was exemplified by a manufacturing concern in 1869 introducing for railroad service an oil for external lubrication, combining the excellent qualities of nature's best lubricating product with other ingredients, producing an article which met all the requirements of the day; . . . a gravity permitting of ready flow, and the sustaining power for support of the ever-increasing loads upon the bearing surfaces. The lubricant has stood the test of service from the date of its introduction, and is now used on the majority of the railroads of this country, as well as on many of the English and Continental lines of Europe."

The rapid development of the locomotive into units of very heavy power, occasioned by the constantly increasing demand of transportation, have gradually produced such radical changes in the manner of operation and maintenance, until lubricating conditions seemed to demand the use of grease on crank pins, and a little later the same lubricant began to find favor when applied to driving journals.

The popular argument in favor of the use of grease on driving journals, is that the bearings require less care and attention than when lubricated with oil. The influence of this argument has been rather far reaching in its effect upon the conditions surrounding the lubrication and maintenance of the most important bearing on the locomotive, with the result that so little care is coming to be used in the proper preparation and maintenance of main journals and bearings that it is to be feared that the day may come when the mechanical department will have to recognize that power conditions with grease lubrication are more of a problem than with oil, and the executive officers of roads will endeavor to find the cause of the increased fuel consumption.

The annual oil bill of a large and important railroad is something of an item and the effective lubrication of the locomotive has a vital relation to successful transportation, but the cost of fuel and locomotive maintenance are subjects which in the present struggle for profitable operation cannot very well be ignored. Fuel consumption for locomotives of this country is above estimation. If the loss of energy of the locomotive under the best conditions be 10 per cent. and the conditions are such as to increase this loss 5 per cent. added annually to the cost of fuel from which no revenue is being derived.

To get the best results from the use of grease in driving boxes, the brasses should be made of good bearing metal, homogeneous and free from all imperfections incident to poor laundry work; they should be bored to proper diameter and given a reasonably good fit, using the same care in all respects as for oil lubricated bearings. The perforated screen of the grease cellar must be made to exactly conform to the diameter and have a full bearing against the journal over its entire surface; otherwise the grease does not feed properly and becomes carbonized resulting in a hot box. The grease cake should be machine pressed to fit the cellar and not allowed to get too thin before it is renewed.

Driving journal lubrication is too important a feature in locomotive operation to relegate to the ignorant and irresponsible.

Running locomotives at high speed that have been designed to pull heavy loads at low speeds, is one of the most common causes of heating of locomotive journals. A locomotive with driving wheels of 54-inch diameter, journals of 10-inch diameter, and a 30-inch piston stroke, running 45 miles an hour has a piston speed of 1,400 feet per minute, and the speed of the surface of the driving journal is 12 feet per second; the speed of both the piston and driving journals being twice what it should be.

The lubrication of the other parts of the locomotive has undergone no great change, except in the character of the lubricants and the economical use of it.

The adoption of types of valve gear, other than the Stevenson link motion, the rubbing parts of which are more accessible and less liable to heat, has assisted much towards more effective and economical lubrication of these parts.

Before entering into a discussion of the effect of lubrication it might be necessary to somewhat understand the laws of friction and the necessity for efficient lubrication.

Unlubricated or solid friction is defined as the force which acts between two bodies at their surface of contact so as to resist their sliding on each other, and which depends on the force with which the bodies are pressed together.

Lubricated friction is defined as the force acting between two oil films so as to resist them sliding on each other and is not dependent on the force between the bodies so long as this force does not squeeze out the oil film and therefore bring about solid friction.

Unlubricated or solid friction is caused as follows:

While a journal may to the naked eye look and be what is commonly called smooth, still there cannot be any such condition on metal, and the surfaces are made up of millions of minute projections. These projections interlock with like or unlike projections on the bearing surfaces, and as the force holding the bodies together is increased so will the force to move them over one another be increased; these projections rubbing in contact causes abrasion.

Widely different classes of metals are used for bearings from that used for journals and the projections on their faces being decidedly different they do not lock so uniformly as like metals.

It is quite apparent, then, that the friction is wholly dependent on the force pressing the two bodies together, and differs with the classes of metals forming the bodies.

The abrasion limit is regulated by the hardness of the softer metal, and the friction is greatest with the soft and least with the hard metals.

Lubricated friction is caused as follows:

The lubricant is (by the rotary motion of the journal) forced or pumped in between the two bodies, with a pressure sufficient to force them apart, and the lubricant adheres to the surface of the journal and the surface of the bearing and does not slip on these surfaces, this adhesion being greater than the cohesion, therefore one film slips on the other film, and one film sliding on another cannot abrade.

The friction, then, is caused somewhat by the cohesion or viscosity of the lubricant, and somewhat by the load and velocity, and proportional to the area of rubbing surface.

This last item shows that it is poor practice to have bearing surfaces of too great an area and unduly reducing the pressure per square inch, as friction is directly proportional to the area and not proportional to the pressure due to load.

Friction represents work and therefore heat must be generated, but it must not be assumed that bearings running at the lowest observed temperatures are giving corresponding low coefficient of friction, as some lubricants have the properties of carrying off heat which is not observed, and thereby showing lower temperatures than some other lubricants but showing a higher coefficient.

To prove this, tests have been made with the following results: With a journal velocity of 306 feet per minute and a load of 350 pounds per square—

With "A" oil, temperature 103° F., coefficient friction .0023.
With "B" oil, temperature 110° F., coefficient friction .0018.
With "D" oil, temperature 130° F., coefficient friction .0035.

This shows that the "B" oil ran with 28% less friction than the "A" oil, although the temperature was 7 degrees higher, and shows that observed temperature does not always indicate the efficiency of a lubricant.

There is another feature of friction that is very important especially in locomotive service, and that is the coefficient on the start; some lubricants show a very great advantage over others in this respect, as the results of the following tests show.

The test equipment was the same as that mentioned above and the starting or static coefficient of friction was as follows:

With "A" oil, coefficient at start .0034
With "B" oil, coefficient at start .0026
With "C" oil, coefficient, at start .005
With "D" oil, coefficient at start .007

The "B" oil is shown far superior to the others, having an efficiency of 30% over the "A" oil and 170% over the "D" oil. This is caused by the "B" oil having superior adhesion qualities at running temperatures, so that it does not drain off the journal readily when at rest, and also having superior body it is not readily squeezed out of the load when at rest.

The foregoing gives in a brief and crude way the laws of friction and also the effect of lubrication in overcoming or rather reducing it, and shows what effect high-class lubricants must have on locomotive service.

The effect of non-efficient lubrication on locomotive service may be divided as follows:

The power losses due to the friction of the various parts.

The loss of metal due to wear.

The various losses of time and material due to heated bearings.

The reduced tonnage and increased coal consumption and delay due to pistons and valves blowing.

The time when engines are held out of service for repairs, and the expense of labor doing repairs.

The first item or power losses due to friction is in general not given much study or consideration in locomotive service, on account of it being a hidden loss and also sometimes from the opinion that it cannot be in any way controlled, or that perhaps any friction reduction that could be made would not cause much benefit.

Circular No. 8 issued by the Experimental Engineering Department of the University of Illinois shows from tests that 1% to 1.2% of the total coal fired is used to overcome the friction of a locomotive. These figures were also used by the Fuel Conservation Committee during Federal control of railroads.

This apparent low percentage of fuel consumption has led some to regard locomotive friction as not being a very important factor; but it must be remembered that only about 6% of the total coal fired is available, so that the friction is approximately one-seventh of the developed power.

It is quite apparent then that for each ¼% that the locomotive friction is reduced that the effective work at the draw-bar is increased 4%, which clearly demonstrates the importance of friction.

In another laboratory test at the University of Illinois they give the following relation of friction horsepower to total indicated horsepower on an Illinois Central railroad locomotive, 2-8-0 type, 209,000 pounds on drivers, 22x30-inch cylinders, using saturated steam:

Miles per Hour	Per Cent. Cut-Off	Indicated H. P.	Indicated H. P. Friction
20	16%	550	121
30	16%	700	140
40	16%	800	136
10	24%	490	76
20	24%	780	125
30	24%	1,000	165
40	24%	1,100	187
10	40%	725	87
20	40%	1,270	127
30	40%	1,600	192
40	40%	1,660	250
10	48%	920	92
20	48%	1,365	150
30	48%	1,665	200
40	48%	1,700	246

The average indicated friction horsepower to total indicated horsepower in the above table is approximately 14% or practically one-seventh as noted above.

It must be assumed, however, that the frictions mentioned include only the friction of the lubricated bearings of the locomotive as it includes the rolling friction of the wheels on the rails, the friction due to the inertia of the parts, etc.

Applied to each 1,000 pounds of coal fired, the above frictions would be approximately as follows:

1,000 pounds of coal fired—
- 40% or 400 pounds lost in gases, cinders, etc.
- 52% or 520 pounds lost in exhaust, etc.
- 8% or 80 pounds available for power.

Then of these 80 pounds 14% is used to overcome friction and 86% of it is available at the draw-bar.

The friction then represents 11.2 pounds or 1.12% of the total coal fired.

The draw-bar power then represents 68.80 pounds or 6.88% of the total coal fired.

To apply the effects of lubrication to the foregoing, let us assume that the above was based on the performance of the "B" oil mentioned previously, and then if the "A" and "D" oils were used, the following would be the results:

	Pounds Coal for Friction	Per Cent. of Total Coal Fired	Pounds Coal for Draw-Bar	Per Cent. of Total Coal Fired	Per Cent. Friction to Draw-Bar
Using "B" oil	11.2	1.12	68.8	6.88	16
Using "A" oil	14.33	1.43	65.66	6.56	21
Using "D" oil	21.72	2.17	58.27	5.82	37

These figures are based on the coefficient of friction tests of the "A," "B" and "D" oils as given in a previous paragraph of this paper.

Note the small differences in the percentage of coal fired makes a very large difference in the percentage of friction to the draw-bar.

Some reduction is necessary to all these percentages to make them exactly correct, because the percentage of fiction is not all due to lubricated areas, but the differentials would be the same, so for a comparative statement they are correct and show clearly the important effect of lubrication on locomotive service.

The area of lubricated surfaces on a 23½x26 Pacific type locomotive is approximately 42,327 square inches, and of this amount 6,950 square inches is contained in the cylinders, valves, pistons, and 6,174 square inches in the driving journals and bearings; with a 73-inch wheel the surface rubbed over per mile is approximately 10,485,000 square inches.

The total areas on a 26½x30 in. Mikado type locomotive are 51,919 square inches, including 10,000 square inches of cylinder and valve area, and 8,140 square inches of riving journal and bearing surface; with a 56-inch wheel the surface rubbed over per mile is approximately 15,808,000 square inches.

Driving journals of locomotives are responsible for a large percentage of friction, and tests have shown that it is an easy matter to supply a lubricant that will reduce these temperatures, but it has been demonstrated that such lubricants will not stand up when the driving journals are subjected to unusual loads, such as unequalized spring gear, or wedges sticking, etc., so that it is somewhat necessary to pay some penalty in friction to insure against mechanical defects which occur frequently.

The lubrication of a locomotive is a semi-automatic mechanical operation that cannot be forced, and no journal can be compelled to take up a greater oil film than its speed and weight and class of lubricant requires, and on reciprocating parts, such as pistons, tests have shown that after a proper oil film is formed any further amount will not reduce friction.

The following notes on piston ring lubrication test will somewhat demonstrate this statement:

With the ring unlubricated the coefficient of friction was about 7½%, with an oil feed of one drop in two minutes the coefficient was about 5%, and with one drop per minute about 3%; a feed of two drops per minute reduced the friction to 1%, and no volume of oil supplied would reduce it below this point.

The locomotive, like any other steam-driven unit, depends greatly for its efficiency on the proper distribution of steam, and its efficiency is low at the best, so that even a small leakage of the valves or pistons is a costly matter in both power and fuel losses.

Railroads in general have no record or knowledge of the separate cost of repairs of lubricated parts, or the cost due to heated bearings, or the frictional load losses, and most roads could use an oil that was 25% below par as a lubricant and so long as it did not cause an unusual number of heated bearings they would not know of its inefficiency with respect to frictional load or frictional wear.

Heated bearings are costly on cars, but they are more so on locomotives, as a car can be set out without much delay, while a locomotive has to come through with its corresponding delay to crews and business.

Piston and valve blows also develop on the line, causing the locomotive to be handled perhaps a hundred miles with reduced tonnage, fuel losses and delays.

If even the frictional load costs of the various lubricants were fully known, it would show that only lubricants of the highest class are suitable for efficient locomotive service irrespective of the cost of the lubricant.

The improvements in the parts of the locomotive; improved oil houses, equipped with adequate storage tanks and self-measuring devices; improved methods of saturating the waste packing and removing the surplus, oil in room kept at proper temperature, the reclamation and reuse of grease; the reclamation and renovation of old waste packing by putting it through a hot oil bath; the proper preparation of grease into forms for driving journal lubrication and into candles and discs for crankpin lubrication; and, above all, the daily attention given the subject by railway officers and subordinates, combined with the greatest of all essentials in the economical use of anything, proper accounting and comparative statements, have all been important factors in bringing about an economy in locomotive lubrication that has not only awakened the wonder of all acquainted with it, but has aroused such an interest in the minds of railroad officers that they have applied the same methods for economy to other departments with the result that it is impossible to estimate the total saving that has resulted directly and indirectly from these methods.

Notwithstanding some opinions to the country, the economical lubrication of the locomotive inevitably means efficient lubrication, for the reason that a more than sufficient oil not only encourages a wasteful and careless application, but also fosters a thoughtless and irresponsible attitude towards locomotive operation and maintenance; while a supply which has been intelligently determined as sufficient tends towards careful use of lubricant and careful operation and maintenance. Even at this late day, when we know that after all the modern term "scientific management" is only a term for finding the best and making it the standard, and although in almost every department of human endeavor limitations recognized as standard are applied, there are those who still hesitate to limit the supply of oil to meet certain conditions, even when the quantity to meet said conditions has been well established.

There is no good reason why a number of men operating the same machine under the same conditions should not be able to lubricate said machine, doing uniform quantities of work, with uniform quantities of lubricant. Any other arrangement simply encourages inefficiency on the part of some of the operators.

The great difference existing between the results obtained on different railroads towards economical and efficient locomotive lubrication is the strongest possible argument that the work of education has not been completed, but really just begun.

The Committee that presented the report consisted of W. J. Fee. (Can. Nat.) Chairman; D. L. Eubank, (Galena Sig. Oil Co.) James Fahey (N. C. & St. L.) J. A. Cooper (Erie) C. McNair, (Galena Sig. Oil Co.) L. Ernest (Soo Line) and E. A. Lacy (B & S).

How Operating Costs Are Being Reduced

How railroad managements are succeeding in reducing the costs of producing railroad transportation are seen in a report just issued by the Bureau of Statistics of the Interstate Commerce Commission. The figures are compiled from 161 reports from 176 steam railroads, and they deal with freight and passenger train service unit costs.

The costs per freight train-mile in July of this year compared with July a year ago were as follows:

	1924	1923
Locomotive repairs	$ .409	.495
Train enginemen	.239	.254
Fuel for train locomotives	.393	.454
Enginehouse expenses	.089	.094
Trainmen	.287	.288
Other locomotive and train supplies	.119	.115
Total selected accounts	1.536	1.700

The cost per passenger train-mile in July of this year compared with July of last year were as follows:

	1924	1923
Locomotive repairs	$ .227	.268
Train enginemen	.130	.127
Fuel for train locomotives	.176	.204
Enginehouse expenses	.057	.061
Trainmen	.146	.140
Other locomotive and train supplies	.085	.090
Total selected accounts	.821	.890

Railroads Have Spent $1,600,000,000 for Equipment in Less Than Three Years

According to an analysis of the railroad rehabilitation program made by Robert S. Binkerd, Vice-Chairman of the Committee on Public Relations of the Eastern Railroads, the railroads of the country have, in the three years since 1921, invested more than $1,600,000,000 in new cars and locomotives. Mr. Binkerd explained that this represents only a part of the improvement effected in the transportation situation since the passage of the Transportation Act of 1920. Mr. Binkerd's statement follows:

"The Car Service Division of the American Railway Association announces that in the first nine months of this year 120,727 new freight cars and 1,657 new locomotives were installed in service on Class One railroads; and that 49,702 freight cars and 285 locomotives were still on order.

"This means that in the three years since 1921, the railroads have bought 454,654 new freight cars and 7,348 new locomotives. As the average price of a freight car is about $2,250, the freight car purchases mean an investment of more than $1,000,000,000 of new capital. The average price of new locomotives is about $50,000 each, so that the locomotive investment is more than $350,000,000.

"During these same three years the railroads also bought and installed approximately 8,000 all-steel passenger-train cars. These cars average about $30,000 apiece and represent an investment of about $240,000,000. Altogether, therefore, during these three years the railroads have invested more than 1,600,000,000 in new cars and locomotives.

"What is going on is the rehabilitation of the railroad plant of the country in the interest of larger, more efficient, and more economical service. This represents only a part of the improvement in the transportation situation since the passage of the Transportation Act of 1920." The equipment purchases by years was as follows:

	Freight Cars	Locomotives
1922	86,350	1,379
1923	197,875	4,037
1924 (nine months)	120,727	1,657
On order Oct. 1, 1924	49,702	285
Totals	454,654	7,348

New York, New Haven & Hartford Railroad Co. Orders Freight and Switching Locomotives

The New York, New Haven & Hartford Railroad Co. has ordered from the General Electric Co. and the American Locomotive Co. seven single phase locomotives of a new type. Five of these units are for freight service and will be used on the main line between Oak Point and New Haven, Conn. The other two are switching locomotives and will be used in general yard service. Whenever double heading, these locomotives will function in multiple unit with the present single phase locomotives.

The design of this type of locomotive is somewhat unusual in that although it is actuated from a single phase trolley it does not have alternating current traction motors. Each locomotive, in fact, contains a traveling substation and will be equipped with a synchronous motor generator set for converting the 11,000-volt 25-cycle single phase supply to direct current, and with direct current railway motors driving the axles.

Power is collected by the usual slider pantograph trolley and is delivered to a main transformer situated in the locomotive cab. This main transformer steps down the trolley potential in 2,300 volts, which drives a single phase synchronous motor direct connected to the main generator. The main generator which delivers current to the traction motors is designed with a variable field and the speed of the locomotive is regulated by field control of this generator. The traction motors are of the standard series direct current railway type, the performance of which is well known. They are geared to the axle through cushion type gears which allow a small movement of the gear ring about the gear hub or center, thus minimizing shock and stresses in the gears and pinions.

Protective devices have been studied with great care. Between the pantograph trolley and the main transformer a time limit automatic oil circuit breaker is installed. Between the direct current generator and the motors there are a high speed circuit breaker and line switches. The high speed circuit breaker will afford protection to both the motors and the generators and will ordinarily prevent the opening of the time limit switch or of the trolley or feeder sectionalizing switches and will thus prevent any interference with the continuous operation of the motor generator set.

The system of control, by varying the field strength of the generator used, in connection with the characteristics of the motor generator set, gives a locomotive which is extremely flexible and adaptable to all operating conditions. It also has the very desirable characteristic of operating at a power factor of unity or better under all ranges of load. The set has been made of sufficient capacity to take care of the rated loads and will also furnish an appreciable amount of wattless current, especially at light loads for power factor correction. This tends to improve the trolley voltage for all load conditions and should be of material benefit in the operation of the entire system.

Red Signals Most Easily Seen

That red signal lights are most easily distinguished from other colors at a distance and require the lowest light intensity for unmistakable recognition, is one of the conclusions drawn from an investigation of the visibility of traffic signals conducted by the Bureau of Standards, Department of Commerce. Green signals came second on the list of colored lights easy to identify, but for street traffic a yellow green is considered preferable to the blue green used on the railroads. Blue ranked third on the list, but was found to require the highest intensity. The railroad yellows, it was found, were often mistaken for orange and red, and a lemon yellow gave much better results.

Several thousand observations were made at distances of 600, 900, and 1,250 feet, using different observers. They were made under daylight conditions, under which the identification of colored lights is most difficult. On the average, a red light of 75 candlepower could be identified at 600 feet, while a green light had to be of 250 candlepower, a yellow 750, and a blue light 1,000. At 900 feet the requirements were 100, 250, and 1,500 candlepower respectively, while at 1,250 feet they were 1,500, 2,500, 3,000, and 7,500.

The tests are a part of a program of standardization of colors for traffic signals in which the bureau is cooperating with the American Engineering Standards Committee, the National Safety Council, and the American Association of State Highway Officials. Under the auspices of these organizations a committee has been formed which has now nearly completed a code for colors of traffic signals and for lights for building exits. This problem includes the use of colored lights on highway vehicles, along highways, and at highway crossings of steam and electric railways; the co-ordinated relation of color, form, position, and number of signals, and their relation to systems of flashing, moving, or other lights; and methods of specifying or defining colors for signal purposes.

Track Scales Show Improvement

Fifty-six and nine-tenths per cent of all the railroad track scales tested by the Bureau of Standards of the Department of Commerce during the past fiscal year passed the prescribed tolerance, the Bureau announces, whereas the year before only 51.6 per cent met these requirements. When the inspection of these scales was first begun in 1914 only 38.2 per cent were satisfactory. It is evident, the Bureau considers, that a very gratifying improvement has grown out of this work, which is of importance to everyone since freight charges are based on tonnage as determined by these scales.

Three special testing equipments are used for this work and they travel all over the country, being on the road the greater part of the year. Railroad track scales will weigh loads up to 150 tons, so that their testing is not an easy matter. The testing must be well done, however, as the prescribed tolerance calls for an accuracy of two-tenths of one per cent of the applied load, or 200 pounds per fifty tons.

Scales were tested during the past year in 37 states and in the District of Columbia. Nineteen master scales were tested, these being used as standards of the company to which they belong, and 1,019 commercial scales.

Scales in the Western district made the best showing, as 60.2 per cent were within the tolerance, while in the Eastern district only 56.7 per cent passed, and in the South the proportion was still lower, only 43.8 per cent being found up to standard. The greatest increases in accuracy over the results of last year's tests were found in these two districts, however.

New Records in Long Locomotive Runs

As a result of the progressive development of locomotive efficiency the Union Pacific Railroad has at present the distinction of making the longest coal-burning passenger run on record. A run of 644 miles from Kansas City, Mo., to Denver, Colo., is now being made with one locomotive.

Other long runs of the Union Pacific without change of engines are:

	Miles
Cheyenne, Wyoming to Pocatello, Idaho	551
Denver, Colorado, to Ogden, Utah	577
Council Bluffs, Iowa, to Denver, Colorado	562
Council Bluffs to Cheyenne, Wyoming	509
Cheyenne to Ogden	483

Interest attaches to the long runs because all railroads are lengthening the distance of locomotive runs. They mean economies because fewer locomotives are required per train mile and more miles per day are available from each engine. There is also a saving in engine house expenses, and in fuel and the wages of train crews.

120,727 New Cars Installed This Year

Class I railroads during the first nine months this year placed in service 120,727 freight cars, a decrease of 13,909 cars compared with the number installed during the corresponding period last year. Of the total number placed in service during the nine months this year 15,771 were installed during the month of September.

By classes, the railroads placed in service during the nine months' period in 1924, 54,406 box cars, 36,526 coal cars and 11,676 refrigerator cars. The difference between that number and 120,727 represents the number of other classes of freight cars placed in service.

The railroads on October 1st also had 49,702 freight cars on order, an increase of 8,226 over the number on order September 1st. Of the total number on order on October 1st, box cars numbered 30,096, coal cars 12,793 and refrigerator cars 2,666. The number of box cars on order was an increase of 10,024 over the number on September 1st.

Locomotives placed in service during the first nine months this year totaled 1,657 of which number 160 were installed during September. Class I carriers also had on order on October 1 this year 285 locomotives.

These figures as to freight cars and locomotives placed in service or on order include new, rebuilt and leased equipment.

99,952 Surplus Cars

Due to heavier demands for transportation the number of surplus freight cars available on October 14 declined to 99,952 according to the Car Service Division of the American Railway Association. This was a decrease of 3,778 compared with the number reported on October 7, at which time there were 103,730.

Surplus coal cars in good repair on October 14th totaled 50,160, a decrease of 2,483 under the number reported on October 7th while surplus box cars in good repair totaled 28,002, a decrease of 2,016 within a week.

Reports showed 8,117 surplus stock cars, an increase of 299 over the number reported on October 7th while there also was an increase during the same period of 120 in the number of surplus refrigerator cars which brought the total for that class of equipment to 3,777.

Practically no car shortage is being reported.

Shop Kinks

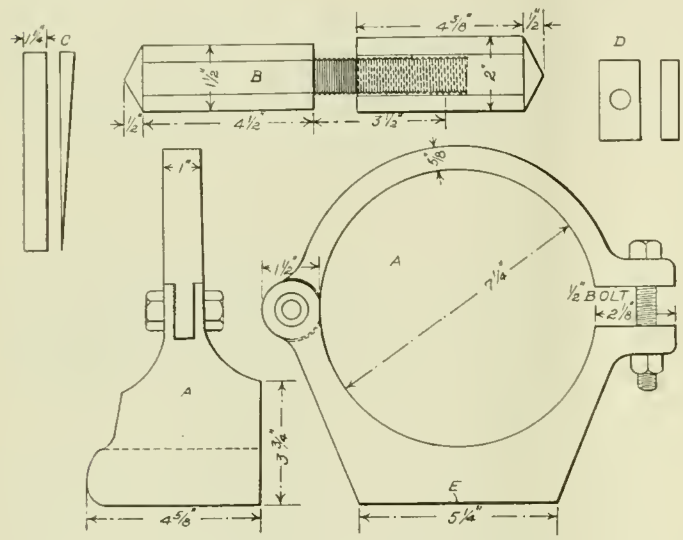
Some Handy Tools in Use in the Erie R.R. Shops

Device for Riveting Gibs to Crossheads

This is a device for holding the heads of copper rivets that are used foor fastening the gibs to the main body of the crosshead. It serves merely as an anvil or holder-on for the rivet.

It consists of two parts, *A* and *B* with their attachments *C* and *D* respectively.

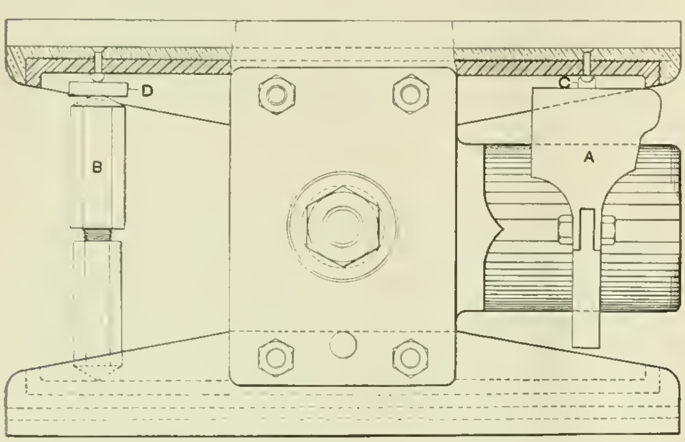
The part *A* is made in two pieces in the form of a clamp that clasps the boss at the piston end of the crosshead, and



Device for Riveting Gibs to Crossheads

is held in place by the clamping bolt. It is set with the flat face *E* parallel to the face to which the gib is to be riveted as shown in the assembled drawing.

After the rivet is in place the wedge *C* is driven beneath its head and the surface *E* of the clamp, thus affording a firm holder-on for the rivet.



Method of Riveting Gibs to Crossheads

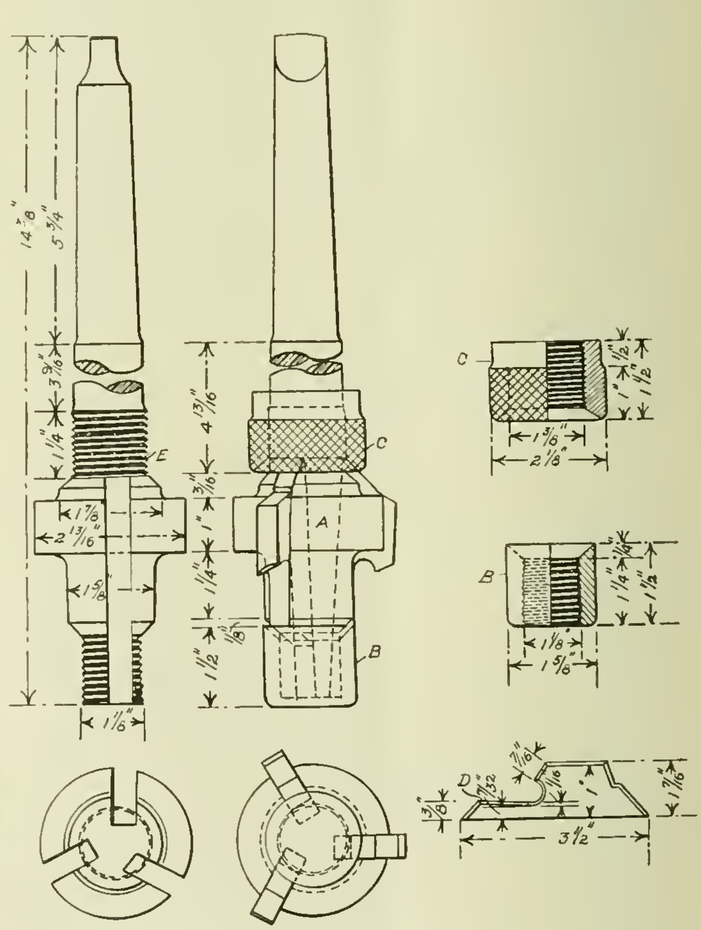
The part *B* is used for the connecting rod end of the crosshead. It is made of a piece of 1½ in. hexagon steel 8 in. long with a distance of 3½ in. turned down to a diameter of 1 in. and threaded, and with a similar piece of steel made into a nut. The bearing piece for the rivet *D* is countersunk to take the pointed end of the nut. When the rivet is in place, it is held there by the bearing piece which in turn, is held by the jack *B* that rests against any convenient part of the crosshead.

Tool for Trimming the Heads of Electrically Welded Tubes

When tubes are electrically welded in place, it is impossible for the welder to leave the ends smooth and uniform in appearance. The eye has become so accustomed to the beaded ends in the firebox tube-sheet that it is regarded as the proper form, hence the tool which is illustrated here.

After the tubes have been welded, the welded metal at the ends is cut into the shape of a bead by this tool.

It is driven by an electric or air motor attached to its shank which has the standard Morse taper. The body of



Tool for Trimming Head on Electric Welded Flues

the tool at *H* is cut with three tapered slots to receive the cutting tools, which are of the shape shown. The lower end of the body is turned to a diameter of 1½ in. and cut with 12 threads to the inch. A thimble *B* screws on to this. This thimble is countersunk at its upper end on a bevel to fit that of the small end of the cutting tool and is so adjusted that when the tools are in place and resting against it, the faces *D* will just enter the tube freely and the cutting edges on the curve will be in place to form the bead. At the same time the thimble B is used, whose diameter is such that it will enter the tube and serve as a guide for the tool.

The tools are held down against the thimble by a clamping collar *C* which is screwed upon the threaded portion *E* and whose knurled surface makes it possible to screw it down tightly against the upper ends of the cutting tools.

With this device the beads can be formed with great rapidity.

Crank Pin Re-turning Tool

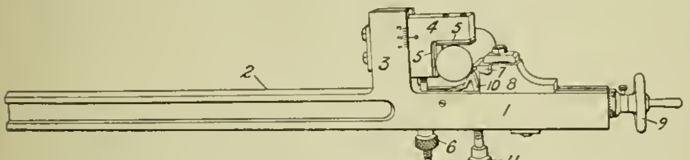
The re-turning of a crankpin on a solid crank has usually been considered an awkward and troublesome job, and one of the first questions asked of the designers of the three-cylinder locomotive was as to how the center crankpin was to be returned.

The tool here illustated is one that will do a smooth and rapid job. It is made by the Sawyer-Weber Tool Manufacturing Company of Los Angeles, California.

The tool consists of a main body (1) having a long tail extension (2) and a post (3) made integral with it. The front face of the post is cut with a dovetail slot in which the angle or V block (4) slides up and down and which can be adjusted to any position by the knurled nut (6), to meet the requirements of different diameters of pins, as indicated by the scale on the post. The inside forces of the block are protected by two hardened steel plates 5, 5.

The cutting tool (7) is held in the tool post (8), by the clamp as shown and the post is fed up into the work by the handwheel (9) which turns a feed screw that moves it.

When the tool has been placed over the crankpin, it and the latter are held together so that the pin is pressing against both of the plates by a bronze shoe (10) which is kept tight by means of a knurled hand screw



Crank Pin Re-turning Tool

(11), which can be adjusted while the work is being done.

In operation the shaft is held on its own centers in the lathe so that the cranks are turning as in regular operation.

When the tool is put in position on the crankpin, as shown in the engraving, the body is on top of the crankpin with the handwheel (9) uppermost and the two adjusting screws (6) and (11) turned out towards the operator and with the tail (2) resting against the lathe bed which prevents the tool from turning with the shaft.

As the shaft revolves, the tail moves up and down against the lathe bed.

In ordinary working, the shaft should be rotated in the slowest back gear speed so that the operator may have a clear view of the cut at all times.

The tool is made the full width of the crankpin and is rounded at the ends so as to cut the fillets.

It is evident that, if the crankpin is worn and is made to turn on the steel plates 5, 5 as on a bearing, its center will move to and fro relatively to the tool and that the surface beneath the tool that is on the longest diameter will be cut away first, and that as the tool is fed in these high spots are cut away first and when the cut goes all of the way around the pin has been trued, and it has been finished on one setting.

In order that all the pins on a shaft may be turned to the same diameter there is a scale attached to the shaft of the handwheel (9) which may be set so as to act as a gauge for the feeding in of the tool.

As the pin is trued from its own surface which, at the commencement of the work may be irregular or eccentric in contour, it follows that the center of the final circular contour may be moved a little from its original position dependent upon the amount of wear. But this cannot exceed one-half the maximum wear at any one point, so that the shifting of that center is practically a negligible quantity.

Snap Shots By the Wanderer

I remember that, when I was a boy at school, a teacher made the remark that a lawyer ought to know everything, because, in his practice, there was no foretelling when the possession of some obscure item of human knowledge might not be of vital importance to him in the presentation of a case. While such an omniscient state of mind for a lawyer or anybody else may be theoretically desirable, we all know it to be practically impossible of attainment. Yet, and I am almost inclined to print the word in large capitals, yet many lawyers, especially railroad lawyers, seem to assume that they know it all, and rely upon their own knowledge and acumen alone before a court or a commission.

It is a comparatively simple matter for a lawyer to take a witness on a technical subject, who is to testify for him, into the privacy of his office and there so post or cram himself that he can conduct a direct examination with credit to himself and justice to his client. But, when he is confronted with the unexpected in the testimony of a witness on the other side, he is helpless unless he has expert technical assistance at his elbow. And why railroad lawyers with the wide variation in technical details that they are obliged to handle do not always insist upon having such assistance instead of practically disregarding it, is beyond me to guess.

As I always like to point my moral with concrete examples, I will cull a few from my own observation and experience.

A railroad built its line many years ago into a city, and the city grew in consequence, until for many miles the road ran through thickly settled residential and business sections. And when the citizens of the great city had grown mighty in their own esteem they forgot their very prop and stay of age and turned to bite the hand that fed them. They demanded great changes in construction and operation. Changes that involved the expenditure of millions. They talked of smoke and noise and danger and discomfort, and the railroad, represented by its attorneys, put up a plea of costs. How little does the public, the demagogue or the legislature care for cost? They don't pay. The cost may be a million or a dozen million; it is all the same to them. They never sit down to count the cost and see whether the victim has sufficient wherewithal to pay it. And so they lost, and the railroad and taxpayers were ordered up to change and pay. It was but a modern repetition of the old fable of the ass and the wolf.

An ass met a hungry wolf. "Have pity on me," begged the trembling ass, "I am a poor sick animal. See! What a big thorn I have stuck in my foot."

"I am so sorry for you," said the wolf, "that I will straightway put you out of your misery and eat you."

Why didn't the lawyers give the matter over to an engineer to study conditions other than finances? And why did they not back their plans by definite proofs, a positive Q. E. D.?

If they had they could have shown that the smoke was invisible; the noise imperceptible above those of the streets; the danger non-existent, and the discomfort so remote that the citizens were in the hands of their political spokesmen, like the client who wept bitter tears all through his lawyer's plea because he did not know that he had suffered so.

Mistakes are costly luxuries, and this is one where a simple demonstration would have put an end to the katydids and katy-didn'ts of the witnesses pro and con in this big controversy.

Now to illustrate the other side of the shield. In the November, 1922 issue of RAILWAY AND LOCOMOTIVE ENGINEERING I told a story of Testimony as is Testimony, in which a witness for the state at a public hearing told a most grotesque and ridiculous story about locomotive construction and operation. It was so bad that it struck some people as being funny. And it was only because it was so very bad that it was detected at all. A mere chance.

It happened in this way. The railroad was represented at the hearing only by the comptroller and its lawyer, the question being mainly financial, when this expert testimony on the part of a certified accountant, who posed as a locomotive expert, was put in. It was quite damaging to the interests of the railroad, and the comptroller was very much exercised over it. So he took it to the superintendent of motive power, who laughed it to scorn. This verdict was taken to the lawyer, who thereupon engaged an engineer to help him out.

For several hours the accountant expert told the most marvelous tales of locomotive performances, that would have been news to the whole mechanical world, thinking that he was talking to comptrollers and lawyers. Then, when all of his direct testimony was in the lawyer asked Mr. Blank, who, up to that time, had been a mere spectator, to come and sit beside him. And then that Mr. Blank proceeded, through the mouth of the lawyer, to give the expert accountant a very uncomfortable two hours in the form of a grueling cross-examination. In short, he was completely knocked out by the man who knew his business with a thoroughness that the lawyer could not touch. Surely when a railroad has a case of that kind to present, the lawyer had best not try to pose as knowing things of which he is ignorant.

A rather amusing sequel to this encounter occurred a couple of years later when these same two men, the accountant and the engineer, crossed each other's paths in gathering material for another case. One experience was enough, and at the hearing the accountant failed to put in an appearance.

Once in a while the biter gets bitten by knowing too much. In the case just alluded to certain locomotive valuations were presented by an engineer for the railroad based upon a price per pound, for the locomotives empty, that had been very carefully prepared. Whereupon the lawyer for the commission calmly announced that they were altogether too high, and that he could produce contracts for the purchase of similar locomotives at a much lower price. This he proceeded to do, and sure enough he had a price that cut far below the engineer's figures. But, and the "but" is a big one, he had failed to notice three little words in the contract. They were, "in working order." As this included about 18,000 lbs. of coal and 20,000 lbs. of water in the tender and some 8,000 lbs. of water in the boiler, it made quite a difference in the cost per pound of the locomotive when they were deducted from the "in working order" weights.

He was a little chagrined at the time, but it would probably be a safe bet to maintain that he would make the same blunder again on some other subject with which he was not familiar.

Cases like these without number can be cited, and the strange part is that the responsible upper officers of the railroads do not insist that their lawyers take on competent advisers if they do not know enough to do it of their own accord.

Turbine Locomotives to Be Discussed at Annual Meeting of American Society of Mechanical Engineers

The Railroad Session to be held during the annual meeting of the American Society of Mechanical Engineers is scheduled to take place at the Engineering Society Building, 29 West 39th St., New York, N. Y., Tuesday afternoon, December 2, 1924, at 2 o'clock.

The Executive Committee has been very much pleased at receiving from Dr. Henry Zoelly, of Zurich, Switzerland, an unusually interesting paper on "Zoelly Turbine Driven Locomotive," which is referred to elsewhere in another column of this issue. Dr. Zoelly will, if his health permits, present the paper himself during a visit to this Country. The increasing interest in the turbine as a means of locomotive propulsion is evidenced by the activities abroad and in this Country. Acceptances have been received from prominent engineers to contribute interesting and valuable discussions on this paper and the Committee on Arrangements anticipates an unusually large attendance at the meeting.

It is expected also that another paper regarding a turbine locomotive will be presented and that further announcements of more than ordinary interest will be forthcoming in connection with this meeting.

It is hoped that advance copies of this paper will be available sufficiently in advance of the meeting to permit preparation of general discussion which will add to the value of the Railroad Session.

Notes on Domestic Railroads

Locomotives

The Southern Pacific Company has placed an order with the American Locomotive Company for one three-cylinder "Southern Pacific type" locomotive.

The Pennsylvania Railroad has just placed an order at its Altoona Works for the construction of 50, 8-wheel switching locomotives of a new design, to be known as the Class C-1.

The Mobile & Ohio Railroad has ordered one Pacific type locomotive from the Baldwin Locomotive Works and 4 heavy Mikado type locomotives from the Lima Locomotive Works.

The Clarendon & Pittsford Railroad has ordered one 0-6-0 switching type locomotive from the American Locomotive Company.

The Southern Railway has ordered 15 Pacific type locomotives, 25 Mikado type locomotives and 10 eight-wheel switching type locomotives from the American Locomotive Company.

The Great Northern Railway is inquiring for 3 simple Mallet type locomotives.

The New York Central Railroad has ordered 15 Pacific type locomotives from the American Locomotive Company.

The Nitrate Railways of Chile have ordered 6 Mikado type locomotives from the Baldwin Locomotive Works.

The New York, New Haven & Hartford Railroad has ordered from the General Electric Company and the American Locomotive Company 7 single phase locomotives of a new type.

The Sugar Pine Lumber Company, Fresno, Calif., has ordered one Mikado type locomotive from the American Locomotive Company.

The Southern Railway is inquiring for one three-cylinder locomotive.

The Lehigh Valley Railroad has ordered 5 three-cylinder locomotives from the American Locomotive Company.

Passenger Cars

The Northern Pacific Railway is inquiring for 10 coaches, 5 baggage cars and 5 combination baggage and mail cars.

The Erie Railroad has ordered one combination passenger and baggage gasoline motor car from J. G. Brill Company.

The Missouri Pacific Railroad has ordered 2 dining cars from the American Car & Foundry Company, and 2 Parlor cars from the Pullman Car & Manufacturing Corporation.

The Interborough Rapid Transit Co. has ordered 150 subway motor cars from the American Car & Foundry Company.

The Wichita Falls & Southern Railway has ordered one combination passenger and baggage motor car and one trailer car from the J. G. Brill Company.

The Lehigh Valley Railroad has ordered 5 all-steel coaches and 3 all-steel dining cars from the Pullman Car & Manufacturing Corporation.

The Texas & Pacific Railway has ordered 10 combination baggage and express cars and 3 combination baggage and mail cars from the American Car & Foundry Company.

The Sugar Land Railway has ordered one combination passenger and baggage gasoline motor car from the J. G. Brill Company.

The Long Island Railroad has ordered 40 steel motor passenger cars for electric service from the American Car & Foundry Company.

The Reading Company has ordered 10 baggage cars from the American Car & Foundry Company and 10 combination baggage and passenger cars from the Standard Steel Car Company.

The Illinois Central Railroad has ordered 30 coaches, 8 compartment coaches from the Pullman Car & Manufacturing Corporation and 6 chair cars, 9 baggage cars, and 10 combination baggage and mail cars from the American Car & Foundry Company.

The Southern Railway has ordered 25 passenger coaches, 10 combination baggage and express cars and 3 dining cars from the Pullman Car & Manufacturing Corporation.

The Great Northern Railway is inquiring for 12 underframes for coaches.

The Delaware, Lackawanna & Western Railroad is inquiring for 30 steel express cars 60 ft. long.

The Alaska Railroad is inquiring for 2 passenger car underframes.

Freight Cars

The Wheeling & Lake Erie Railroad has ordered 1,000 steel box cars of 50 tons' capacity from the Standard Steel Car Company.

The National Tube Company, Pittsburgh, is inquiring for 10 freight cars of 70 tons' capacity.

The Long Island Railroad is inquiring for 15 caboose cars.

The Mobile & Ohio Railroad is inquiring for 200 double-drop-bottom steel frame gondola cars of 50 tons' capacity and 150 steel-frame hopper cars of 50 tons' capacity.

The Great Northern Railway is inquiring for 27 refrigerator car underframes.

The Buffado & Susquehanna Railroad is inquiring for bids on 400 all-steel hopper bottom coal cars of 55 tons' capacity.

The Chicago, North Western Railway is inquiring for 1,000 box cars, 1,000 automobile cars, 500 stock cars, 500 flat cars and 200 refrigerator cars.

The Chicago, Rock Island & Pacific Railway is having 146 gondola cars repaired at the shops of the Western Steel Car & Foundry Company.

The Central Railroad of New Jersey is inquiring for 50 box cars of 40 tons' capacity.

The Norfolk & Western Railway is inquiring for 3,000 all steel gondola cars of 57½ tons' capacity.

The Chicago Burlington & Quincy Railroad is asking for bids on the repair of 1,000 gondola cars of 50 tons' capacity.

The Texas Company is inquiring for from 500 to 1,000 tank cars of 10,000 gal. capacity.

The Standard Oil Company of Brazil is inquiring through the car builders for 10 tank cars of 50 tons' capacity.

The South Indian Railway is inquiring through the car builders for 20 tank cars of 30 tons' capacity.

The Pere Marquette Railroad has ordered 22 underframes from the Pressed Steel Car Company.

The General Sugar Company, Havana, has ordered 12 cane cars of 30 tons' capacity from the Magor Car Company.

The Chicago & North Western Railway has been authorized to purchase new equipment at a cost of $8,000,000 to include 3,500 freight cars and 50 steel passenger cars.

The St. Louis-San Francisco Railway will repair 400 or 500 gondola cars in its own shops.

The Great Northern Railway has ordered 900 box cars from the General American Car Company.

The Southern Railway has placed an order with the American Car & Foundry Company for 535 box cars.

The Interstate Public Service Company, Indianapolis, Ind., is inquiring for 40 new gondola cars.

The North American Car Company is inquiring for 150 refrigerator cars.

The Northern Pacific Railway is reported to be inquiring for 800 gondola cars.

The Long Island Railroad is inquiring for 15 caboose cars.

Buildings and Structures

The Atchison, Topeka & Santa Fe Railway has awarded a contract for the construction of an addition to the boiler shop at San Bernardino, Calif.

The Southern Railway recently let contracts for a 25-stall roundhouse and machine shop, 50 by 100 ft., at Lynchburg, Va., also a boiler shop 40 by 48 ft., at Asheville, N. C.

The Pacific Fruit Express Company has plans for expending about $450,000 on car shops and equipment at Nampa, Ida.

The Reading Company is reported to be preparing preliminary plans covering enlargements to its car and locomotive shops at Reading, Pa.

The Minneapolis, St. Paul & Sault Ste Marie Railway plans the construction of a new engine terminal, roundhouse, service shop, and an 80-car passing track at Park Falls, Wis.

The Boston & Maine Railroad has placed a contract covering the erection of an engine house addition at Springfield, Mass., to cost approximately $45,000.

The Long Island Railroad has awarded a contract covering an addition to its shops at Morris Park, New York.

The New York Central Railroad plans the construction of a two-story shop at Buffalo, New York, to cost $35,000.

The Atlantic Coast Line Railway is preparing plans covering a new engine house and shops at Albany, Ga., to cost approximately $75,000.

The Minneapolis & St. Louis Railway is preparing plans covering the construction of a new car repair shops at Clear Lake, Iowa, to cost approximately $100,000.

The Southern Railway has placed a contract covering the construction of a 25-stall reinforced concrete roundhouse, machine shop and boiler house, at Asheville, N. C.

The Detroit, Toledo & Ironton Railroad plans the construction of a new railway yard, engine house and repair shop, at Lima, Ohio, which is to be made a divisional terminal.

The Chicago, Rick Island & Pacific Railway plans the construction of repair shops and engine house at Cedar Rapids, Iowa, estimated to cost approximately $30,000.

The Texas & Pacific Railway plans enlarging its shops at Marshall, Texas, by the addition of new car repair sheds and machine shops.

The Western Maryland Railway has placed a contract covering the construction of a locomotive repair shop and engine house at Dunbar, Pa., to replace the shop recently destroyed by fire.

The Detroit, Toledo & Ironton Railroad plans the construction of a car shop at Flat Rock, Mich.

The Chicago, Rock Island & Pacific Railway has awarded a contract for the construction of a coach shop at Shawnee, Okla.

The Atchison, Topeka & Santa Fe Railway plans the construction of a one-story addition at its shops at Topeka, Kans.

The New York Central Railroad has awarded a contract for the construction of an upholstery shop at West Albany, N. Y., to cost approximately $93,400.

The Pennsylvania Railroad has awarded a contract for the erection of a reinforced concrete locomotive coaling plant at the new terminal, Toledo, Ohio.

The Reading Company plans to enlarge its car and locomotive repair shops at Reading, Pa.

Items of Personal Interest

T. H. Butler has been appointed roundhouse foreman on the Illinois Central Railroad, with headquarters at Jackson, Tenn., vice W. Wilcox promoted. **George Allen** has been made night foreman at the plant.

Harry B. Baker has been appointed superintendent of special service of the Atchison, Topeka & Santa Fe Railway, with headquarters at Topeka, Kans.

James M. Shields is appointed assistant day roundhouse foreman of the Chicago, Rock Island & Pacific Railway, with headquarters at Pratt, Kans., succeeding **A. R. Lane**, transferred.

J. B. Gutherie has been appointed assistant general foreman of the Baltimore & Ohio Railroad, with headquarters at Pittsburgh, Pa.

W. C. Hilton has been appointed assistant to the vice-president in charge of operation of the Atchison, Topeka & Santa Fe Railway, with headquarters at Chicago, Ill.

K. C. Spatz has been appointed assistant superintendent of fuel conservation on the Missouri-Pacific Railroad, with headquarters at St. Louis, Mo.

L. J. Ballard, has been promoted to night roundhouse foreman of Missouri-Kansas-Texas Railroad, with headquarters at Dallas, Texas, succeeding **F. H. Brown**, who has been appointed general foreman, with headquarters at Denison, Texas.

B. K. Stewart, foreman of the Middle Division of the Pennsylvania Railroad, has been transferred to Altoona Works and appointed foreman locomotive finishing shop.

M. H. Slater has been appointed assistant roundhouse foreman of the Rock Island, with headquarters at Herrington, Kans., succeeding **Bert Mehorray**, transferred.

Thomas K. Ubil, a car inspector in the Bellwood shops on the Cresson Division of the Pennsylvania Railroad, retired on October 1st, with a total of 35 years of service.

A. H. Baldridge has been appointed night roundhouse foreman on the Santa Fe System, with headquarters at Winslow, Ariz., succeeding **J. W. DeSpain**, resigned.

The office of master mechanic of the Omaha division of the Chicago, Burlington & Quincy Railroad has been re-established and **G. B. Pauley** has been appointed to the position as master mechanic, with headquarters at this point.

W. Wilcox has been made general foreman on the Illinois Central Railroad, with headquarters at Jackson, Tenn., succeeding **A. R. Sykes**, resigned.

Ed Robertson has been appointed road foreman of equipment of the Chicago, Rock Island & Pacific Railway, with jurisdiction over sub-divisions 51-a, 51-c, 53 and 53-a, with headquarters at El Dorado, Ark., to succeed **W. Wood**, who has been transferred.

H. L. Marsalis, welder foreman on the Illinois Central Railroad, with headquarters at McComb, Miss, who has been made traveling welding instructor on the system.

The mechanical affairs of the Florida division of the Seaboard Air Line Railway have been removed from the master mechanic at Jacksonville, Fla., and the office of master mechanic of the Florida division has been created. **H. Y. Harris** has been appointed to the position, with headquarters at Tampa, Fla.

Supply Trade Notes

The Superheater Company, New York, is preparing plans for the construction of a one-story powerhouse, at East Chicago, Ind.

The Gibb Instrument Co., Bay City, Mich., manufacturer of electric welding machines and electric heating machines, has broken ground for a new modern plant, at Bay City.

H. T. Heath has been appointed western department manager of the **Hegeman Castle Corp.**, of Chicago, Ill., which is owned and controlled by the **National Railway Appliance Co.**

W. L. Garrison has been appointed assistant manager of the engineering department of the **Ingersoll-Rand Co.**, New York City.

C. F. McCuen, general sales agent of the **Camel Company**, Chicago, Ill., has been appointed sales representative of the **W. H. Miner, Inc.**, Chicago, Ill.

John D. Maurer has been appointed general superintendent of the Bay View plant of the **Illinois Steel Co.**, Milwaukee, Wis., succeeding **R. B. Charlton**, deceased. Mr. Maurer has been assistant general superintendent.

The Detroit offices of the **Whiting Corp.**, Harvey, Ill., have been moved from 3000 Grand River avenue to 650 Baltimore avenue, West.

The Western Tie & Timber Company, St. Louis, Mo., is preparing plans covering the erection of a tie plant at Edwardsville, Ill.

The General American Tank Car Corporation, whose general offices are in Chicago, Ill., has purchased a large track of land near Good Hope, La., and according to report, will commence the construction at once of a large plant for building tank and freight cars.

J. S. Stearns, of Ludington, Mich., has purchased the **Stafford Roller Bearing Truck Co.**, Lawton, Mich.

The Pullman Car & Mfg. Company is asking bids on passenger car finishing plant at its work at Pullman, Ill., to cost approximately $500,000.

The Locomotive Firebox Co., 310 South Michigan avenue, Chicago, Ill., manufacturer of the **Nicholson Thermic Syphon**, has appointed **C. M. Hannaford**, American National Bank building, Richmond, Va., as representative in that territory.

H. K. Porter Locomotive Co., Pittsburgh, Pa., plans the construction of an office building at that point.

Carl Gebuhr has been appointed manager of sales of the **Gidding & Lewis Machine Company**, with headquarters at Fond du Lac, Wis.

The Mt. Vernon Car Manufacturing Company, Mt. Vernon, Ill., will construct a one-story brick and steel foundry to cost approximately $300,000.

L. G. Pritz has been appointed vice-president in charge of all operations of the **United Alloy Steel Corp.**, Canton, Ohio.

A. H. Weston, sales engineer of the **T. H. Symington Company**, with headquarters at New York City, has been elected vice-president in charge of sales of the **Car Device Company**, with headquarters at Richmond, Va.

The Cameron & Barkley Co., Charleston, S. C., has been appointed district representative in the Charleston district for the **Central Iron & Steel Company**, Harrisburg, Pa.

The Standard Railway Equipment Company and the **Union Metal Products Company** have moved their Chicago office to the Strauss building, So. Michigan avenue, Chicago, Ill.

Michael H. Connelly, formerly sales agent for the **American Car & Foundry Company**, has resigned to become manager of sales for the **Albany Car Wheel Company, Reading Car Wheel Company** and the **General Steel Casting & Machine Company**, with headqurters at Newark, New Jersey.

R. D. Bartlett, assistant to the president of the **Ryan Car Company**, Chicago, Ill., has been promoted to vice-president. **Reginald Cooke** has been promoted to secretary and treasurer.

Paul M. Etters, sales engineer of the **National Carbon Company**, has resigned to become eastern manager of the **E. A. Lundy Company**, with headquarters at Pittsburgh, Pa.

Lawrence Miller, assistant sales manager of the **Carnegie Steel Company**, with headquarters at St. Louis, Mo., has resigned to become manager of the sales department of the **National Enameling & Stamping Company**, with headquarters at St. Louis, Mo.

Obituary

Carl J. Mellin, who, for many years was consulting engineer for the American Locomotive Company, died at his home in Schenectady, New York, on October 15. Mr. Mellin was born in Westergotland, Sweden, on February 17, 1851, and received his early academic and engineering training at Alingsos and Gothenberg, Sweden.

At the age of 19 he entered the State Railway shops and after remaining there for three years secured a position as draughtsman with the Goteborg Marine Engine Works. This was in 1873, and for twenty years thereafter he was engaged in marine engine work.

After four years of this work in Sweden, he went to Scotland in 1877, where he was connected with the Robert Napier & Sons Marine Works. He remained there until 1880, when he returned to Sweden to serve as superintendent and mechanical engineer of the Thorskag and Eriksbergs Marine & Shipbuilding Co.

After seven years he came to the United States, in 1887, and located in New York City with the Dynamite Gun Co., which was engaged in the exploitation of a pneumatic gun for throwing charges of dynamite. The best known example of its work was the cruiser, *Vesuvius*, with the designing of which Mr. Mellin was associated. While in New York he married an American lady and shortly afterwards accepted a position with the Richmond Locomotive Works as a mechanical engineer upon whose shoulders were placed the responsibilitiy for the designing of the engines for the first battleship *Texas*, the contract for whose construction had been taken by that company.

It was about this time, that is in the early nineties, that von Borries, De Glehn, Webb and others were developing their several systems of compound locomotives in Europe and the subject was attracting a great deal of attention in this country. Owing to his great familiarity with the construction and efficiency of compound engines in marine service, Mr. Mellin naturally turned to the application of this same construction to the locomotive. He accordingly designed and patented a form of intercepting valve for compound locomotives, which, in its application became known as the Richmond compound, and which was extensively used. It was his first public contribution to locomotive work and his faith in this form of construction he held until his death. It was shortly after this, in 1894, that he was made the chief engineer of the company.

He held this position until 1901, when the Richmond Locomotive Works was absorbed in the formation of the American Locomotive Co., when he went with the latter company to Schenectady as consulting engineer, a position which he held until his death.

Carl J. Mellin

It was while occupying this position that he went abroad to study locomotive practice for his company and especially with reference to the Mallet articulated compound locomotive. He reported that, as constructed, after the designs of Mr. Mallet, it was too small and unsuited in that as well as in the details of its construction to American practice, but that the principle of the design could be used and adapted to the requirements of pushing service in the United States. He accordingly started the designing of a heavy Mallet compound locomotive for such work, and in it he was obliged to cast aside many well established precedents, both in the locomotive practice of the country and the original Mallet designs. The result was a locomotive intended for heavy pushing service on grades. The design had been worked up and shown for a year and a half or so before an order was received. The first having been for the Baltimore & Ohio R. R. Its success was so great that its use rapidly extended to regular road service where large numbers are in use.

Among other of his activities Mr. Mellin was prominent in the introduction and adaptation of the Walschaerts valve gear to American locomotives as well as the superheater, and the first successful power reverse gear is also due to him. In fact more than fifty patents were assigned to him mostly for locomotive details. He was an ardent advocate of the use of the three-cylinder locomotive, and, true to his old love, was engaged in the designing of a three-cylinder compound locomotive at the time of his last illness.

Mr. Mellin traveled extensively in Europe and America in the interest of naval and railway engineering, and because of his distinguished service in the engineering field, he was knighted and decorated by the late King Oscar of Sweden. Among the organizations with which Mr. Mellin was connected were the American Society of Mechanical Engineers, the American Railway Association, the Society of Swedish Engineers, the N. Y. Railroad Club and many local clubs.

In spite of his seventy-three years, Mr. Mellin was actively at work in his chosen field up to the time of his last illness only a few days before his death.

It is difficult to make an estimate of the character of such a man at short range. Of his contributions to engineering work enough has been said to insure him a lasting memory. But back of that is the man whose genial and whole-hearted welcome of his friends to his office and his house was most delightful. He never seemed in so much of a hurry or so pressed with work that he did not have the time to talk over matters of interest to his profession. He was very emphatic and positive in the statement of opinions which he had formed as the result of his own investigations, and could always support them by an array of most convincing facts. While on points that were outside the range of his own observations and study, he had the true scientific attitude of eagerness to learn and to know the truth and with all the simplicity of a child. He knew his own worth as any such a man must have known it, but in discussing anything in the development of which he had played an important part he spoke in the most impersonal way and a stranger would never have guessed his personal connection with it. It was the attitude of a man so secure in his own position that he felt no necessity of proclaiming it, but rather acted with the inate modesty of his character and failed to mention things for which he had the right to claim the credit. His attitude was that of a modest man preeminent in his work.

George W. Lyndon, president of the Association of Manufacturers of Chilled Car Wheels, died at Chicago, Ill., on October 7. Mr. Lyndon was born at Rochester, N. Y., on February 16, 1859.

After graduating from high school in 1877, Mr. Lyndon studied law with Charles K. Ladd, Kewanee, and Turner A. Gill, at Kansas City, Mo., until 1880, when he entered railway service with the Kansas Pacific, at Kansas City, Mo. Shortly thereafter he was transferred to Omaha, Nebr., on account of the consolidation of the Kansas Pacific with the Union Pacific. He remained with the Union Pacific as chief clerk of freight accounts until 1885, when he became traveling auditor of the Kansas City, Ft. Smith & Memphis, with headquarters at Kansas City. In 1887 he was appointed freight auditor, resigning in 1889 to accept a position as feight auditor of the Chicago, Kansas City & St. Paul, now a part of the Chicago Great Western Railway. In 1890 he resigned to become general auditor of the Griffin Wheel Company and the Ajax Forge Company. Later he was made manager of the improvement and review department of these companies, which position he held until 1907. In 1908 he was made western secretary of the Railway Business Association and in the same year he was appointed secretary and treasurer of the Association of Manufacturers of Chilled Car Wheels, which position he held until October 27, 1914, when he was elected president, with headquarters at Chicago.

Mr. Lyndon was an outstanding figure in the development of the chilled iron wheel. He handled for the Association of Manufacturers of Chilled Car Wheels all of the numerous details in connection with the standardization of wheels for steam, electric railway, and industrial cars. He was untiring in the development of the fundamental properties of chilled iron which brought him in close contact with the research laboratories of Purdue University, at LaFayette, Ind., University of Illinois, at Urbana, Ill., and Bureau of Standards, at Washington, D. C., which ultimately resulted in the establishment of a research laboratory by the Association of Manufacturers of Chilled Car Wheels. The results of these research inquiries were summarized and placed before the railway public in the form of addresses before various railroad clubs. The publications in pamphlet form have been given wide distribution and are favorably known throughout the world wherever chilled iron wheels are used.

Mr. Lyndon possessed a fine personality and was especially gifted in presenting information to the various committees through which it was necessary for him to work. His relationship to the Wheel Association is well stated in the following resolution passed at their annual meeting, October 15, 1924: The association unanimously adopted the following minute:—

The members of the Association of Manufacturers of Chilled Car Wheels, assembled in annual meeting at New York, October 15, 1924, expresses its deep sorrow at the death of George W. Lyndon, who was to have presided over this meeting and who for many years has been the honored president of this association. Mr. Lyndon was an able executive, a loyal and true friend and a charming associate and the members of this association will cherish as a priceless heritage the memory of their delightful companionship with him.

New Publications

Books, Bulletins, Catalogues, Etc.

Practical Mathematical Analysis, by H. von Sonden, translated from the German by H. Levy. 195 pages, 6 in. by 9 in. E. P. Dutton & Co., New York.

It is to be understood at the outset, that this book is not one for the novice, but is suggestive for the trained mathematician. It is doubtful if a reader who had never heard of the French revolution would get much if any historical information out of Carlyle's history. But to one who is thoroughly familiar with the whole story it is most delightful. So here, it will be necessary to be more than familiar with the various branches touched upon to obtain much if any help from this book.

In the preface the author urges the study of the higher branches of mathematics in the technical schools, together with training in analysis, in order to provide the engineer with tools for his use. And this training should be such as to enable the engineer to express his results ultimately in numerical form, which is simply axiomatic.

With this object in view the eleven chapters into which the book is divided treat of the general considerations of numerical and graphical calculation, the slide rule and calculating machines, graphical integration and differentiation, solution of equations and a variety of other matters.

It appears, however, that too much regarding the reader's prior training is taken for granted. Take the discussion of the slide rule and calculating machine for examples. It is doubtful if anyone who had not handled the slide rule and learned all of its quirks and turns would get a very clear idea of how to use the instrument from the book. And so too of the Burkhardt calculating machine which is taken as an example. The illustration is on so small a scale that the figures to which reference is made can only be read with the aid of a magnifying glass, and it is doubtful if the novice could operate the machine from the description given. To one who is familiar with the machine, the statements regarding it are lucid enough.

And this holds for nearly every subject treated. It may be summed up in the statement that it is very learned but not at all clear.

Elasticity and Strength of Materials Used in Engineering Construction, Section V, by C. A. P. Turner, 129 pages, 6 in. by 9 in. Published by the Author, Minneapolis, Minn.

The announcement in the preface is that the discussion in this volume is directed toward the elucidation of the underlying principles by which a determination of the precise number and form of triangular frames, which should be combined in a truss to secure the maximum stiffness and minimum weight of bridge structures can be made. It also calls attention to the fact that the weight of long spans differ from 50 to 100 per cent as indicated by a discussion before the American Society of Civil Engineers.

The book, proper, opens with the axiomatic statement that preliminary to the design of any frame structure the service, which it is to render, must be first known. It then gives a brief sketch of the development of bridge loadings, and discusses the conventional uniform load and then urges a rational treatment of the equivalent uniform load and suggests a method for reaching the desired results. In dealing with the subject of impact and one or two other matters, the author, following in the footsteps of many others, forgets that the reader may not be as familiar with the subject as he is, and so neglects to indicate the meaning of some of the symbols in his formulae, which renders them useless to such uninformed readers.

The book takes up the matter of wind pressures, stresses on curves and that much neglected feature of bridge design the aesthetics of the structure. And later on brings out an exemplification of the old adage that "what looks right is right" by showing that in a certain instance the most beautiful design was not only that but also the stiffest and lightest.

While the book is a purely technical discussion of the subject it is so well written and the facts and arguments are presented in such an interesting manner that it is very easy reading. And through it all there is a strict adherence to the economic theory of steel railroad bridge design, which is announced on the title page to be the topic in hand. So it deals with the economic theory of design of beams and plate girders, the economic types of height and panel length; it discusses the relative merits of rivetted and pin connected trusses; it gives a clear analysis of foundation work, and closes with a chapter on long span railroad bridge structures, in which the arch and cantilever spans are compared, and finally reaches the conclusion "that the arch is the most economic long span structure where the foundations are suitable. The cantilever arch ranks next, then the cantilever and braced suspension."

It is hardly possible that all bridge engineers will agree, at once, with everything that Mr. Turner has written, but he has at least given them something most interesting to read and something well worth while thinking about.

Locomotive Superheaters: The Superheater Company, of New York and Chicago, have just reissued their Superheater Round House Chart. It illustrates the Locomotive Superheater and gives a description of it and instructions for operation and maintenance. The chart is 37½" x 25", is printed on heavy coated stock, and is suitable for framing. The surface of the chart is especially treated so that dirt or grease can be washed off easily without injuring the chart. For convenience, the chart is also reproduced as Bulletin 11. Copies of these publications will be sent upon application to anyone mentioning this publication.

Locomotive Feed Water Heaters. The Superheater Company, of New York and Chicago, have just issued Spare Parts Lists for Feed Water Heater Condensate Return Tanks and Washout Apparatus as Bulletins H-3-a and H-3-b, respectively. These bulletins will be of particular interest to storekeepers on roads using Elesco Heaters and will be sent to readers of this publication on request.

Railway and Locomotive Engineering

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The Bethlehem Twin-Span Turntable

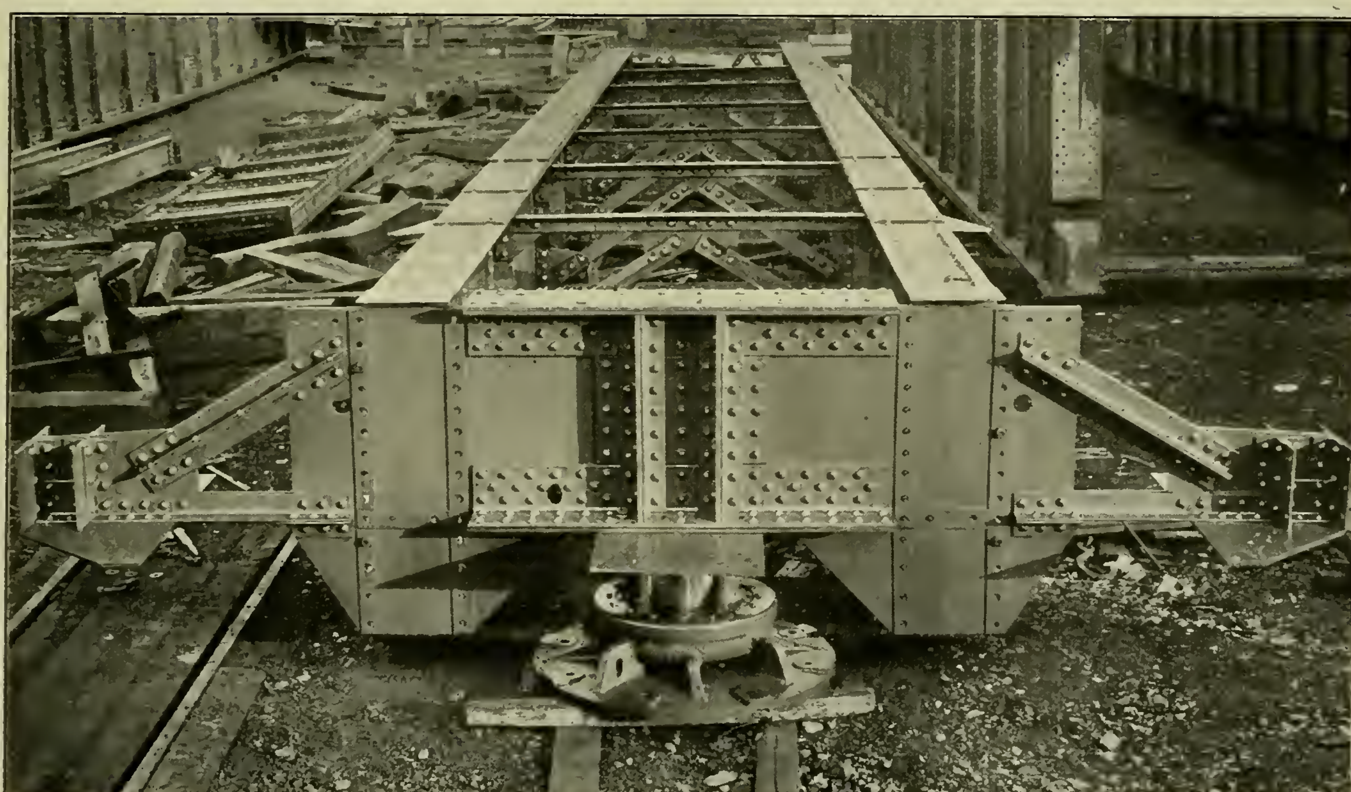
The Adaptation of the Rigid Fulcrum to the Purposes of a Turntable

When Mr. Albert H. Emery designed the testing machine that is known by his name, he introduced a novelty in the fulcrums that was such a distinctive feature that it stood out more prominently than any of the many others embodied in the machine. The peculiarity of these fulcrums was that instead of a hardened knife edge resting on a hardened steel seat, a thin piece of steel was pressed into the lever and the base forming a solid construction between the two. As the lever moved, the fulcrum was bent to permit of the movement.

With the size of the metal strip of the fulcrum adjusted to properly meet the requirements of the load imposed and the magnitude of the lever movement involved, it was found that the resistance to motion was less than that offered by the knife edge fulcrum, while the distortion of the metal was never sufficient to stress it beyond its limit of elasticity.

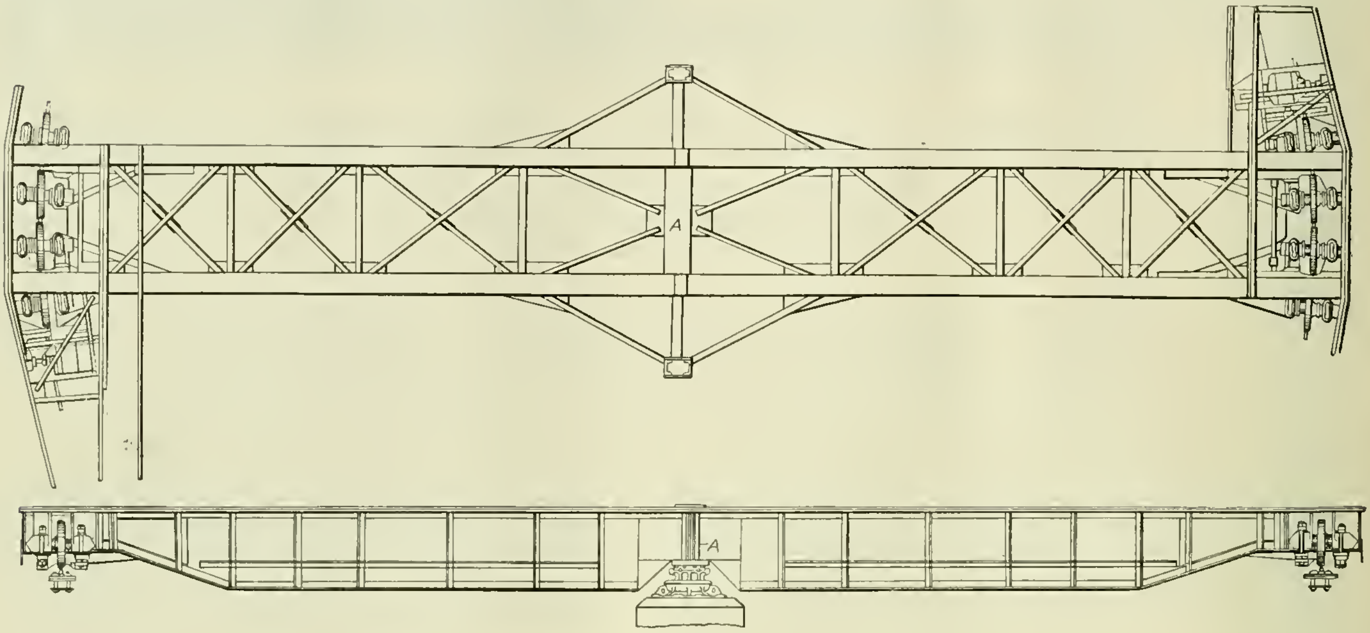
The same principle has been successfully applied in the designing of the twin-span turntable of the Bethlehem Steel Co.

A reproduction of a photograph of one of these turntables was published in the May, 1924, issue of Railway & Locomotive Engineering in connection with a description of some of the features of the new Acca engine terminal of the Richmond, Fredericksburg & Potomac R. R., near Richmond, Va.

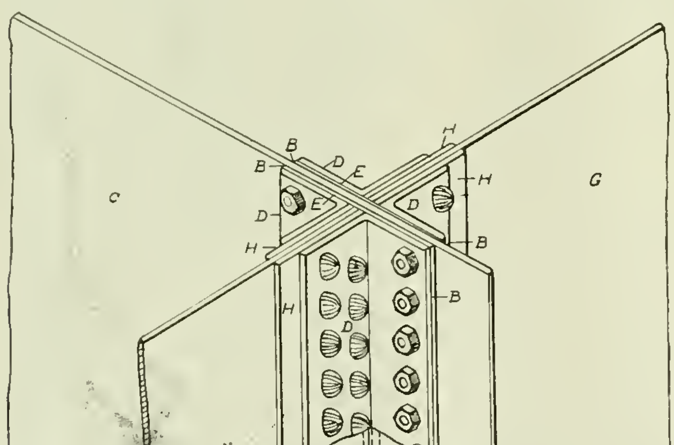


Bethlehem Twin-Span Turntable Showing Center Plate and Bolster

Drawings of a 75 ft. turntable of this class are here presented for the purpose of explaining the distinctive features of the construction. The most prominent and outstanding of these is a special connection which permits of such vertical flexibility between the two like spans, joined over the center bearing and comprising the turntable, that each of the three points of support for spans carries its proper proportion of the dead weight and the live load. These flexible connections provide, not only for the span deflections when under a load, but also allow the ends of the spans sufficient freedom to adjust themselves automatically to any ordinary inequalities in the level of the circular track, or to a settlement of the center foundations.



Plan and Side Elevation of Bethlehem Twin-Span Turntable



Isometric View of Connection Between Girders and Center Bolster of Twin-Span Turntable

With this feature and the three points of support it is not necessary to balance a locomotive on the turntable as it is free to turn over a circular track of normal inequalities no matter how unevenly loaded. The result is that a shorter turntable can be used than where balancing is necessary.

As will be seen from the illustration of the plan and side elevation of a 75-ft. turntable, the table consists of two deck plate girder spans, joined together and supported at the center and with their outer ends carried by the usual circular rail located near the wall of the pit. The general appearance is that of a plain, straight, rigid plate girder with no flexibility, and it would seem as though a bearing at the center and at one end would be all that it would be possible to obtain.

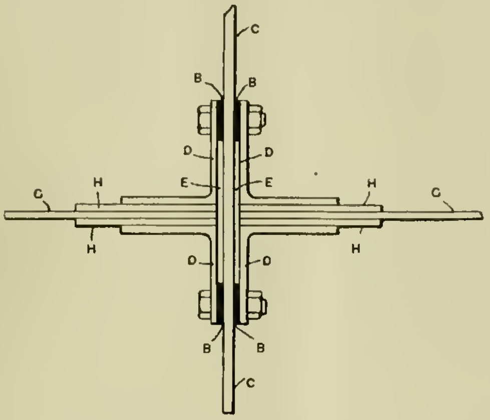
Referring to the illustrations, it will be noted that there is a single deep cross girder at the center to which the long plate girders, extending from the center to the pit rails, are fastened. The center bearing, consisting of shoes and equalizing pin, is also attached to this central girder, the whole turning on a phosphor bronze disc bearing on a distributing base casting.

The vertical plate of this central girder is indicated as *C* on the plan and isometric elevation of the connection details. Bolted to this plate there are four vertical strips *B* and four 8 in. by 8 in. angles *D*. The strips *B* are $\frac{1}{4}$ in. thick and extend vertically for the whole depth of the plate except, for the short distance of 3 in., where the hinge or pintle plates *F*, having the same thickness as *B*, are laid in and run across the whole width of outstanding legs of girder connecting angles *D*.

The vertical web plates *G* of the main girders, their fillers *H*, and connection angles *D*, all terminate at the heel of the angles and stand away from the cross girder by the thickness of the plates *B* and *F*.

This leaves a space *E* of $\frac{1}{4}$ in., between the connection angles of the main girder and the plate *C* of the cross girder, for the whole depth of main girder connection, except where it is filled in by the pintle plates *F*. The main girder is, therefore, supported at the center by the outstanding legs of the angles *D*, where they are bolted against the strips *B*.

It is evident that these thin outstanding legs of the angles, only $\frac{5}{8}$ in. thick, cannot hold the main girders as cantilevers from the center cross girder. The result is that the legs of the angles are bent as the outer ends of the girders are raised or lowered by their carrying wheels running on the circular rails. With outer end being lowered the connected end of the girder pivots about the



Horizontal Section of Connection Between Girders and Center Bolster

hinge strips *F* and its upper corner of web moves out and widens the space *E* at the top while the lower corner of web moves inwardly and narrows the space *E* at the bottom.

If, on the other hand, the circular rails are higher than the normal level of the main girders would require, either because of the settling of the central foundation or frost action on the rail supports, the outer ends of the main girders are raised; then the upper corner of the main girder is moved inward and the upper space *E* is narrowed, while the lower corner moves outward and *E* is widened.

The hinge plates *F* are located 2 ft. 10¼ in. below the top of the girder in a 75 ft. turntable, so that the relative movements of the end of the table and the top of the girder about the hinge plate are as 1 to 13.13, so that for a large error in leveling of circular track, say ½ in., there is distortion or bending of the leg of the angle at the top of about 1/32 in. As this takes place in a plate ⅝ in. thick and over 7¼ in. from its point of riveted support, its elastic limit is not exceeded at the extreme or top of girder height and this distortion is decreased to nothing at the hinge plate *F*. Below the hinge plate *F* the distance to the bottom of the girder is only 1 ft. 8½ in. so that the stress induced is proportionately less than for upper sections of angles.

For longer turntables the depth of the girders being constant, as a standard, this distortion of the angles is proportionately less, and thus offsets increases in deflections due to the longer girders and constant depth. In the case of partial failure of the center foundation, or a settlement of several inches, these same connection angles will take a permanent set and then continue to flex for the circular track inequalities as noted above.

This feature of making structural members articulate vertically, without recourse to a pin connection, is further positively held to a strictly vertical action by means of a continuous horizontal lateral system from end to end of the turntable passing through the center of the hinge plate *F*. This bracing system is twice as wide as the spans at the center of the table, hence the table is made extra strong transversely and at that point where it flexes vertically, the gusset plates (composing the lateral system where passing through the hinge plates *F*) flexing vertically with the spans.

This, then, is a very simple solution of that much desired appliance, an articulated turntable that is particularly strong laterally, and it has been accomplished by the utilization of the flexibility of ordinary structural materials within the elastic limit.

The Three-Cylinder Locomotive

A Presentation of Its Advantages by the Engineers of the American Locomotive Company

Two papers setting forth the advantages of the three-cylinder locomotive have recently been presented by J. G. Blunt, mechanical engineer, and James Partington, manager of the engineering department of the American Locomotive Co., respectively. Mr. Blunt's paper was read before the St. Louis Railroad Club and Mr. Partington's before the Southern and Southwestern Ry. Club.

In this introduction Mr. Blunt said that as we approach the end of the first hundred years of locomotive service and reflect on the increasing benefits which the reciprocating steam locomotive has given to the transportation problems of today, we are mindful of the seventy-five or more experimental years which preceded it in the making of that historic event. Surely that occasion will, in due time, be celebrated as a reminder of the principles developed during those experimental years, which are the basic ones involved in our locomotive construction today.

In those early years, the problem required a locomotive having the greatest starting power, with means for exerting the maximum tractive effort gradually throughout its speed range. The problem today is likewise to produce an individual power unit, possessing this fundamental principle and capable of exerting its full tractive power per unit of weight on each driving axle, while attaining speeds within the limit of safety to human life, the locomotive mechanism and to the right-of-way generally, while requiring a minimum of maintenance, with the most economical use of fuel per ton mile hauled.

We have today various means of locomotive power transmission other than the reciprocating steam locomotive, such as, electric locomotives using various mechanical and electrical means of transmitting power to the driving wheels, the steam turbine, and various forms of internal combustion engines using gasoline or crude oil which are receiving marked attention, both here and abroad, as sources of locomotive power. Difficulty in power transmission from a constant speed motor to the driving wheels, requiring a speed range from nothing to maximum, offers difficult mechanical problems or involves large expenditure in utilizing electrical transmission.

Various speakers have predicted a decline in the ability and efficiency of the reciprocating steam locomotive to meet the major transportation problems of the future. While these predictions may eventually be confirmed, the fact remains that no locomotive power unit has been produced on a commercially economic basis to cope with the reciprocating steam locomotive in cost of operation per ton mile under average conditions in long distance heavy duty transportation. It, therefore, remains an economic necessity to make the steam locomotive as efficient a power unit as possible until those predictions have reached a degree of commercial utility warranting their general substitution in place of the reciprocating steam locomotive. Many noteworthy efforts have been made, or are now undergoing experimental development, possessing great potential value.

With the foregoing assumption, the problem now is to select that application of the reciprocating principle for the larger steam locomotive units most nearly approaching these commercial requirements and one which will, under varying conditions, deliver the maximum power, speed and economy, at the same time requiring the operation of the fewest number of units to handle the traffic, while transporting the maximum tonnage over an existing railway line.

Thorough investigation has convinced many that the single expansion, three-cylinder application most fully meets these commercial requirements at this time, although future improvements will undoubtedly follow its more or less general use.

it enables the steam in the cylinders to be used more expansively through a larger percentage of its running time, while having greater starting ability, accompanied by a substantial fuel saving for tonnage hauled; there is less danger of frame failure on account of the smaller outside cylinders, with less overhanging pressure acting through the rods and axles on the frames; the six exhausts per driving wheel revolution produce a more even draft on the fire, enabling the use of larger exhaust nozzles, with less back pressure in the cylinders, resulting in still greater fuel economy.

Mr. Partington's paper was devoted exclusively to the three cylinder locomotive. He opened with a brief resume of the work that has been done in this country and in Europe in the construction of and experimentation with that type of machine; and then, in a few paragraphs set forth its advantages. These naturally check with those given by Mr. Blunt, but upon which he enlarged.

As for increase of tractive power, the arrangement of

Name of Railroad	Class or Type	Cylinders Inches	Working Pressure Lbs.	Dia. of Drivers Inches	Driving Wheel Base ft.	& in.	Weight on Drivers Lbs.	Total Weight Lbs.	Trac. Power Lbs.	Trac. Power with Booster Lbs.	Factor of Adhesion
New York Central	4-8-2	25 x 28	200	69	18	--	241,500	367,000	64,700	75,700	3.73
Lehigh Valley	4-8-2	25 x 28	200	69	18	--	246,500	369,000	64,700	- --	3.81
South Manchurian	2-8-0	22½ x 26	180	54	15	10	194,000	263,500	56,000	- --	3.46
New York, New Haven & Hartford	0-8-0	22 x 28	200	57	16	4	245,000	245,000	60,300	- --	4,07
Louisville & Nashville	2-8-2	1-23 x 28	200	63	17	10	245,500	334,000	65,700	- --	3.73
	2-8-2	2-23 x 32	200	63	17	10	245,500	334,000	65,700	- --	3.73
Chicago, Rock Island & Pacific	4-6-2	22½ x 28	190	74	13	6	187,000	305,000	46,400	- --	4.03
Missouri Pacific	4-6-2	22½ x 28	190	73	14	4	185,500	302,500	47,100	- --	3.91
Missouri Pacific	2-8-2	1-23 x 28	200	63	17	10	244,000	334,000	65,700	- --	3.71
	2-8-2	2-23 x 32	200	63	17	10	244,000	334,000	65,700	- --	3.71
Wabash	2-8-2	1-23 x 28	200	64			258,000	351,000	66,000	- --	3.80
	2-8-2	2-23 x 32	200	64			258,000	351,000	66,000	- --	3.80
Southern Pacific	4-10-2	1-25 x 28	200	63½	22	10	306,000	430,000	76,900	87,800	4.00
	4-10-2	2-25 x 32	200	63½	22	10	306,000	430,000	76,900	87,800	4.00
Delaware, Lackawanna & Western	4-8-2	25 x 28	210	73	19	--	260,000	392,000	64,300	- --	4.00

Table of Characteristics of Three Cylinder Locomotives Built by the American Locomotive Company

Undoubtedly the most efficient wheel arrangement obtains when connecting the middle cylinder to the crank axle and the outside cylinders to an adjacent axle, thus more evenly distributing the cylinder power throughout the mechanism, with the least slipping tendency or dynamic effect.

In comparing two locomotives with the same wheel arrangement, one having two cylinders and the other three, and assuming equal boiler pressures and driving axle loads, the normal tractive power can be materially improved without increasing the slipping tendency, at the same time increasing the starting power by double the normal tractive power increase.

In considering locomotives of the sizes required on our trunk lines at this time, no application offers as many practical advantages throughout the speed range as a locomotive equipped with the 3-cylinder principle.

It straightens out the tractive power fluctuations for each driving wheel revolution: It delivers more tractive power per pound of weight involved; it reduces the dynamic effects on the rail; it provides more even power distribution to the mechanical parts, with correspondingly reduced stresses in the locomotive mechanism and right-of-way construction; it eliminates the nosing effects of the inside cylinder entirely, while materially reducing this effect in the outer cylinders by reason of their smaller diameter; it requires less truck lateral resistance, with correspondingly less wear from hub and flange pressure;

the cranks of the two-cylinder locomotive is such that with an 85 per cent cut-off, if the mean tractive effort is 40,000 lbs., at one point in the revolution it will rise to 50,000 lbs., and unless there is sufficient weight on the drivers the engine will slip.

With the three-cylinder arrangement with the same cut-off and mean tractive effort, the greatest tractive effort at any point of the stroke will not exceed 43,000 lbs., thus requiring much less adhesive weight to prevent slipping than the corresponding two-cylinder design.

It is, therefore, evident that with three cylinders we can get a very high starting torque more uniformly applied, permitting a reduced factor of adhesion.

It is also evident that with the train once in motion, it can be hauled by a three-cylinder locomotive operating at a considerably shorter cut-off than that necessary for a two-cylinder locomotive.

On account of the more uniform torque the factor of adhesion can be reduced about 15 per cent.

In nearly all heavy freight locomotives of the two-cylinder type it is possible to balance in the main wheels but a small part, if any, of the reciprocating weights and this makes it necessary to place an excess amount of reciprocating counterbalance in the other drivers.

By reducing the size of the outside cylinders in the three-cylinder locomotive as compared with a two-cylinder engine of like power the amount of reciprocating counterbalance is materially reduced.

In many cases it is possible to cut down the dynamic augment in this way by as much as 35 per cent of the tractive power, which permit of approximately this same amount of static load, which will correspond to a ten per cent. increase of tractive power.

Then there is a so much greater uniformity of drawbar pull with the three-cylinder engine that it is easily conceivable that the more even drawbar pull of a three-cylinder locomotive when hauling a 25 per cent. heavier train will be less destructive to draft gears and cars than the two-cylinder locomotive, which on account of having cranks set at 90 degrees may have a jerking increment approximately 20 per cent. greater than the three-cylinder locomotive of the same mean drawbar pull.

The foregoing tabulation gives the principal features of the three-cylinder locomotives that have thus far been built in accordance with the general design of the locomotive illustrated in the November issue of RAILWAY & LOCOMOTIVE ENGINEERING and is an interesting detail of the work already accomplished.

Locomotive Feed-water Heating

By JOHN M. LAMMEDEE

Abstract of a Paper Presented to the St. Louis Railway Club

In venturing upon this discussion of the subject of locomotive feed-water heating, it is my purpose rather than to dwell at any great length upon the history of the subject, to trace the several developments rather sketchily, accompanying my statements with references to the sources from which the information given you can be elaborated upon by the reader of these proceedings through reference to those sources if he so desires. The general history of the subject of locomotive feed-water heating will be covered by referring you to a paper by J. Snowden Bell, which will be found incorporated in the 1917 and 1918 proceedings of what was then the American Railway Master Mechanics' Association. From Mr. Bell's paper, it will be seen that the idea and the various attempts at the practice of locomotive feed-water heating date back to the very beginning of the locomotive itself. While in the nature of things, the author of that paper could hardly have been able to cover every instance in which locomotive feed-water heating has been attempted during the past ninety years, he has nevertheless, referred to a sufficient number of instances to show that there has not been a single decade since the beginning of locomotive history when some one or more attempts have not been made to further the development of the locomotive feed-water heating idea, either as those attempts have been disclosed to the records of the patent office or by actual application to locomotive service.

The purpose of feed-water heating in locomotive practice is unique in that, thus far, it constitutes that only procedure through which attempt has been made to recover waste heat, lacking which practice this heat escapes to the atmosphere and is forever lost. At locomotive terminals to be sure we find in use means whereby to wash and refill locomotive boilers with water that is blown out of the boiler coming in off the road; likewise means whereby the raw makeup water used to filling the boiler is given its initial heating through the process of absorbing some portion of the heat from the water blown out of the incoming boilers, but in neither case do these practices serve to effect any part of the saving which can be brought about by recovering some portion of the heat discarded by the locomotive when in operation out on the line of road, as is brought about by taking advantage of the heat absorbing capacity of the water in the process of its delivery from the tender to the locomotive boiler.

A practical measure of the opportunity for economy by means of feed-water heating may be arrived at through consideration of the fact that between the condition in which we find water in the locomotive tender and the condition in which this same water in the form of steam is admitted to the locomotive cylinders, there must be added to each pound of water transformed into steam superheated 200 degrees and ready for utilization in the cylinders, something like 1,275 thermal units of heat. Now, inasmuch as 1/100 of this number of heat units is 12.75 and since the unit measure of heat is that quantity required to raise one pound of water through one degree rise in temperature, it follows that for every 12.75 degrees rise approximately in temperature of the feed-water made use of by a modern locomotive, there should be required 1/100 or one per cent less heat than is necessary in case where the preheating of the water does not take place.

Assuming the practice of preheating boiler feed-water through the absorption of heat discarded by the engines with exhaust steam and assuming, furthermore, this waste steam to be available at a pressure of eight pounds, at which pressure its temperature is 235 degrees; it is quite practicable with waste steam at this pressure to increase the temperature of the feed-water up to within 15 or 20 degrees of the temperature of the steam itself. Hence with steam available as stated, a delivery temperature of 220 degrees is well within the range of possibility. We will assume that the temperature of the water in the tank is 60 deg., hence the initial temperature, subtracted from the final temperature, leaves us a range of 160 deg. through which, under these conditions, the feed-water can be heated. By dividing 160, the feasible rise in temperature, by 12.75, the number of degrees rise necessary whereby to effect one per cent economy in fuel, we find that, roughly, 12½ per cent heat saving can be brought about under the conditions assumed and in the manner defined. Other benefits related to this one in such a way as to give an additional saving in fuel will be referred to later in this discussion.

The two principal sources of waste heat in locomotive operation are, as will be noted by reference to a typical locomotive heat balance, waste steam as exhausted by the engines and waste gases discarded by the boiler. A convenient reference for the benefit of those interested in making a study of the locomotive heat balance is found in circular No. 8, subject "The Economical Use of Coal in Railway Locomotives," issued by the University of Illinois under date of September 9, 1918. From this it will be seen that better than 50 per cent of the heat originally contained in the fuel as fired is lost out of the stack in the form of waste steam, while another 15 per cent is discarded in the form of waste gases. In inefficiently maintained and operated locomotives, the former loss may easily run as high as 60 per cent, and the latter as high as 20 per cent. Between the two, as sources of heat for the feed-water heating process, it is to be noted that the steam discarded by the engines carries with it fully three times as much heat as do the exhaust gases discarded by the boiler. Because of this fact, and also because of the fact that the relative heat carrying capacity of a pound or a cubic foot of steam, as compared with a like measure of the gases is such that upwards of 50 times the rate of heat transfer can be derived from the former as compared with the latter, we naturally turn to waste steam as the most prolific, as well as the most practical source from which heat can be absorbed by the boiler feed-water.

You have been given a rule-of-thumb method whereby to determine the percentage of heat recovery through the practice of feed-water heating, namely, by dividing the rise in temperature by 1/100 of the number of heat units necessary to convert a pound of boiler feed-water at tank temperature into superheated steam as used in the cylinders. It might be of interest at this point to determine what quantity of water at 60 deg. temperature it is theoretically possible to heat up to 220 degrees through the utilization of one pound of exhaust steam at the assumed pressure of 8 lbs. per square inch. The steam tables show that the temperature of steam at eight pounds pressure is 234.8 deg. Fahr.; also that each pound of saturated steam at that pressure carries 1,158.6 b.t.u. above that in water at a temperature of 32 degrees.

Now in making use of this pound of steam for feed heating purposes we proceed to take out of it the water of condensation which, at 220 deg. temperature, will have substracted from the total heat available, 220 minus 32 or 188 b.t.u. The original heat value, 1,158.6 b.t.u., minus the 188 units extracted with the water of condensation, leaves us 970.6 b.t.u. remaining to be distributed. Since we propose to heat water from tank temperature at 60 deg. to a boiler feed temperature of 220 deg. the rise in temperature is the difference in these two values or 160 deg. Inasmuch as each degree rise in temperature requires one b.t.u., we may then expect to heat as many pounds of water up to 220 degrees as 160 is contained in the remaining heat, 970.6 b.t.u., or 6.06 lbs. of water.

In the open type heater, by virtue of direct contact between the steam that does the heating and the water that is heated, we automatically combine with this 6.06 lbs. of water the 1 lb. of water of condensation which gives us 7.06 lbs. of water heated and available for boiler feed purposes for each pound of exhaust steam conveyed to the heater. The ratio of steam to water is as 1 is to 7.06 or 14 per cent. Just here we derive a further advantage inasmuch as 14 per cent of the water required by the boiler is condensed from exhaust steam, it is therefore distilled water. The feed-water heater thus effects a 14 per cent absolute water treatment, and this percentage of scale, which would otherwise be admitted to the boiler with a corresponding amount of raw water from the tender, is prevented from entering the boiler and retarding its performance to at least 14 per cent of whatever degree the efficiency of the boiler is impaired by the presence in it of scale forming material. The extent of the saving in water itseelf is less than 14 per cent by that percentage of the steaming capacity of the boiler required to operate the boiler feed pump. This is around 2 per cent, hence the net water recovery is 14 minus 2, or 12 per cent.

It may be noted here that the aforementioned values result from the use of those systems of heating that retrieve and return to the boiler the condensate derived from the steam that is utilized in heating the water from the tender. Inasmuch as 14 per cent of the water required by the boiler, in cases where open type feed-water heaters are used, comes as condensate at its maximum temperature, and is combined automatically with the water from the tank, it remains for the apparatus to heat not 100 per cent of the water going to the boiler but 86 per cent and therefore, but 12 per cent of the steam need be taken away from the exhaust nozzles as against 1 divided by 6.06 or 16½ per cent as is required in European practice where closed type heaters are used and where the water of condensation, with its heat, and totally free from scale, is drained away to the track. There is thus a lesser interference with the drafting of the locomotive in the case of the open type heater than there is in the case of those types of apparatus wherein sufficient quantities of steam must be taken away from the exhaust to heat the full 100 per cent of water being handled into the boiler.

The three leading systems now employed in Europe are: in England, the Weir system; in Germany, the Knorr-Bremse system, and France the Callie-Potonic system.

It is understood that some 15,000 of the Knorr-Bremse equipments are in use in Germany alone. Outside of Germany the principal distribution of the Knorr-Bremse system appears to be in the Scandinavian countries and in other neighboring states. Outside of Great Britain the Weir system appears to have its principal distribution in the British dependencies in Africa, India and Australia. In limited numbers Weir heaters have been tried on North American railroads, and lacking advice to the contrary, it is believed that one or two of them are still in service on the Canadian Pacific in the vicinity of Montreal.

Other European feed-water heating systems that appear to have gained at least a limited application are the Rihosek, a waste-gas type of heater in use on certain locomotives on the Austrian national railway system, and the Dabeg heater, which is an open type or direct-contact heater in which the heater supply and the boiler feed pumps are operated by means of a connecting rod from the eccentric crank actuating the Walschaert valve gear. Both of these heaters are illustrated in the 1923 proceedings of the International Railway Fuel Association.

The average person in contemplating feed-water heater practice looks upon it as essentially a means of conserving fuel, and so it is. The extent to which the feed-water heater, as such, is able to conserve heat has already been indicated. In addition to this there is a further saving in heat and therefore, a greater fuel saving, providing the apparatus be used for the purpose rather than the purpose of increasing capacity, because of the increase in boiler efficiency coming about by virtue of the lower rate of combustion on the grates, this being a direct consequence of the action of the apparatus in providing part of the heat necessary and therefore requiring less from the fire. Whereas, heat recovery may amount to between 10 per cent and 12 per cent net, under the average run of conditions, the additional saving, due to the increased boiler efficiency may be anything up to 6 per cent or 8 per cent or 10 per cent, which shows that locomotive feed water is capable of effecting economy in fuel ranging anywhere from 12 per cent to 20 per cent actual operation. Taking standby losses and irregularities of operation into consideration, the advocate of feed heating practice feels that he is quite conservative when he holds out the prospect of a net saving of 10 per cent in fuel, clear of overhead and maintenance charges.

It has been noted that there is in addition to the fuel saving, a saving in water in proportion as steam is drawn off from the exhaust passages of the locomotive and is condensed and returned to the boiler. Generally speaking, this should be around 12 per cent or 14 per cent, and while it may or may not represent an appreciable item from the standpoint of the value of the water alone, it does amount to a considerable item when it is taken into account that, depending upon local conditions, the occasional water stop may be omitted, thereby saving not merely time on the run but the effects of especially bad water, if the station omitted bears that characteristic, and likewise, in some appreciable measure, the damage to equipment resulting from the stopping of freight trains, particularly in heavy drag service.

In approaching the conclusion of this discussion it is desired to cover hastily certain practical considerations that are daily encountered and dealt with in the use of locomotive feed-water heating apparatus. The practical railroad man, observing that a considerable portion of the steam ordinarily passing out of the exhaust nozzle in the heater equipped engine is diverted to purposes other than draft, is given some concern as to the effect of such diversion on the draft and surmises that a tightening up of the nozzle should be made in order that there may be available sufficient draft with which to burn the fire. For such as these it will be stated that the feed-water heater, in the performance of its function as a fuel saver, automatically takes care of the draft by requiring that less fuel be burned and therefore that less draft be required wherewith to burn the fuel. Not only is this the case, but by virtue of the fact that a lesser amount of fuel is burned there results a higher rate of boiler efficiency and, commonly, a surplus of draft so that, as frequently as not, it should be possible to enlarge the diameter of the nozzle rather than necessary to reduce it. Any alterations actually required in the diameters of nozzles, should they tend to a reduction in the size of the nozzle, are more likely occasioned by altered fuel and boiler conditions rather than because of interruption to the draft on account of the feed-water heater.

There comes up in this connection, the disposition on the part of certain engineers who are accustomed to adjusting the position of cut-off by the sound of the exhaust at the stack, to increase cut-off to the extent of one or two notches on the quadrant in order to keep the engine "barking" as she did before the heater was applied. Unless, in this case, the locomotive is loaded down with sufficient additional tonnage to make up the difference or conditions are such that the difference can be made up in increased speed of train, such engineer would be operating his locomotives with unnecessary extravagance in the use of steam. The difference in exhaust comes about, as explained, because of the taking off of 12 per cent to 14 per cent of the steam for the benefit of the heater and the engineer should be made to understand this fact and become accustomed to the sound of the softer exhaust on his feed-water heater equipped engine.

At the outset the introduction of the feed-water heater was attended with a good deal of speculation concerning the oil that might possibly be carried into the boiler with the condensate from the exhaust steam. In each of the feedwater heating systems that have been offered for your consideration, there are provided means for extracting this oil, either from the exhaust steam on its way to the heater or from the condensate on its return to the tender. There may be those in this audience who are still concerned about the merits of this argument, hence it is to be understood that these remarks are submitted purely by way of information and are not to be construed in any sense as a recommendation. The facts of the matter, respecting the oil-in-the-boiler argument, concerning which not a few alarming admonitions have appeared in print, are that experience in the field has brought no less than five or six of the largest users of feed-water heaters to the point where this question has been thrown into the discard as unworthy of serious consideration. Not only have several responsible users of the open type heater arrived at this conclusion, but there are, as well, those among the principal users of the non-contact heating system who are disclosing their attitude in the matter by dispensing with the carrying of filter cloths in their store-stocks.

Another item that has been more or less of concern to the users of locomotive feed-water heating apparatus is the boiler check problem. Thanks to the endeavors of boiler check manufacturers, there are now available several designs of checks well adapted to the conditions of feeding by means of the double-acting single-cylinder pump. Certain of these have already proven themselves out in service with very gratifying result. Aside from this, however, there are users of locomotive feed-water heating equipment who have successfully overcome their boiler check difficulties by resort to the practice of spring loading their checks, even though their checks are not of a design devised with a view to boiler feeding by means of the pump.

The users of locomotive feed-water heaters have manifested much concern over the methods and results of the tests to be applied to their locomotives thus equipped. Inasmuch as the feedwater heater is a temperature raising mechanism, does it not follow that when the use of a thermometer discloses the fact that the heater has done as much as can be expected of it, in the way of increasing the temperature of the water passing through it, that the apparatus has demonstrated its ability to perform the work for which it was intended? If then, as is generally conceded, there is merit in the principle of feed-water heating, is not the thermometer all that is required to prove the sufficiency or lack of sufficiency of the device in question? Tests beyond this point should be not so much for the purpose of checking the performance of the heater since that has already been disclosed by means of the thermometer, as for the purpose of a check on proper methods of utilization, they become properly a check on the operating force and against operating conditions rather than on the equipment itself.

On the assumption that fullest advantage is taken of operating conditions, if one is disposed to go into the question further, a check of evaporation per pound of fuel used with and without the heater will invariably show a gratifying percentage of improvement in favor of the former condition. Should this not actually show in a lesser consumption of fuel in proportion to the work done, the heater certainly should not be held accountable for possible misuse of the greater quantity of steam that has just been shown to have been generated. A properly made dynamometer car test is, of course, conclusive, but in view of the extreme simplicity of the method first outlined i.e., by the use of the thermometer on the discharge side of the apparatus, it would seem that a good deal of unnecessary time, trouble and expense is being incurred in the making of tests by the dynamometer car method.

Finally, let it be said that locomotive feed-water heating apparatus, while it has been proven entirely workable and reliable in service, is not a type of apparatus that thrives on neglect. Considering that unlike other important factors that serve to economize in the use of locomotive water and fuel, the feed-water heater is altogether on the outside of the locomotive, dispensing with the requirement that front ends be opened, fires killed or arch brick removed in order to gain access to it, there can be little excuse for neglecting the simple routine of inspection and test whereby to keep it in operating condition and to insure against failure out on the road. Remember, too, that failure of the feed-water heating apparatus does not necessarily involve failure of the locomotive, since unlike other equipment, again, there is a substitute means of performing one of its essential functions, i.e., that of feeding the boiler.

In view of the benefits derived from the use of this apparatus, reasonable precautions should be taken against the failure of the equipment itself through daily inspection and test. The working mechanism of the feed-water heater is essentially that of a water handling pump, concerning which there is no occasion for mystery, and if at the terminals at which heater-equipped locomotives are being attended, there will simply be placed on some one individual the responsibility for a periodical check of the condition of this equipment, the users of it will very shortly find themselves adopting toward it that casual and familiar attitude that they have long since learned to hold toward other and much more complicated apparatus.

New Locomotives for the Norte Railways of Spain

By W. R. Taliaferro, Railway Equipment Engineer, Westinghouse Electric & Manufacturing Company

A most important railway electrification project in Spain is that of the "Pajores grade" on the Norte Railway, which connects the North Seacoast (Bay of Biscay) at Gijion, and the coal mines on the northern slope of the Cabertoria Mountains with the inland cities. The service on this section is very congested and with steam operation and the present equipment, the capacity of the line has been reached.

The "Pajores grade," which is the section being electrified at the present time, is about 40 miles long and of very light single-track, wide gauge (5 ft. 6 in.) construction, consisting almost entirely of curves and 2 per cent grade passing through many tunnels. The tunnels which form fully fifty per cent of the total length of the grade are very wet and many of them are over a mile long. Wet, slimy rails and gas from the steam locomotives have made the present operation of the grade very difficult.

The electrification is intended to accomplish three things: Increase the capacity of the line, remove the danger of asphyxiation of crews in tunnels, and effect a large saving in cost of power by the substitution of water power for steam and by regeneration down the grades.

It is the intention with electrification to handle trains of 300 metric tons trailing with one locomotive and 600 metric ton trains with two locomotives, one at each end. These trains are exceedingly light due to the maximum draw bar pull being limited to 30,000 pounds by the draft gear on the cars.

Six 3,000 volt D. C. regenerative electric locomotive equipments, complete with air brake equipment for the locomotive and vacuum brake equipment for the train brakes, have been furnished by the Westinghouse Electric International Company for this electrification.

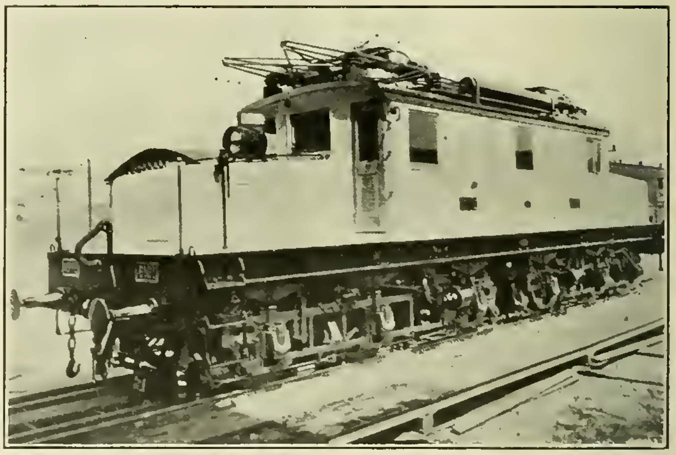
The design of the mechanical parts has been furnished by the Baldwin Locomotive Works. The mechanical parts were built in Spain and the complete locomotives assembled by La Sociedad Espanola De Construccion Naval.

The locomotives are of the six-axle type with two six-wheel swivel trucks. Each axle is driven through a single helical gear by an axle-mounted motor having a one-hour rating of 270 hp. All motors are wound for 1,500 volts and operate two in series from the 3,000 volt D. C. line.

The locomotive cab is of the steeple type, having a large hood at each end. These hoods contain the major part of the auxiliary apparatus, such as air compressor, exhausters, blowers, motor-generator set and storage battery and their automatic control apparatus.

The control equipment is similar to that supplied by the Westinghouse Company on the Paulist and Chilean State Railways, and has been designed to give the greatest simplicity and flexibility to the control of the locomotive. All switches such as line, resistor and motor combination switches required to break heavy currents are of the electro-pneumatic unit type. Motor combinations and regenerative circuits are set up by electro-pneumatic cam-operated switches and regenerative regulating and stabilizing resistance switches are of the electro-pneumatic unit type, but without blowout coils.

The control is arranged for three speed combinations, consisting of series, series-parallel and parallel, or one-third, two-thirds and full speed. The series or one-third



Electric Locomotive for the Norte Railway of Spain

speed motor combination is obtained by connecting all six motors in series. In this combination, eleven resistance notches are provided and one running notch.

The series-parallel or two-third speed motor combination is obtained by connecting in parallel two sets of three motors in series. Here again, eleven resistance notches and one running notch are provided. The parallel or full speed motor combination is obtained by connecting in parallel three sets of two motors in series. Eleven resistance notches and one running notch are provided, but normally only nine of the resistance notches will be used or required.

Changes from one combination to another will be effected by means of a motor combination handle on the master controller, so arranged that the locomotive may be accelerated through the three speed combinations in sequence or in any one of the three motor combinations as desired. This arrangement of speed control makes the locomotive extremely flexible, which is of great importance where trains are to be handled on heavy grades and where adhesion is low and the rolling stock light, as it is on most European railroads.

Due to the very light track construction (light rails, wide tie spacing and light bridges) limiting the axle loading to a very low figure, it has been necessary to limit the total locomotive weight to 92.5 U. S. tons, which has been accomplished by special design throughout the locomotive to save weight wherever possible. In the control equipment, a large saving in weight has been accomplished by blowing air through the grid resistance which would be required for a self-ventilated grid resistance on a locomotive of this rating.

The locomotives are arranged for regenerative breaking in all three motor or speed combinations, and the system employed is that which has met with so much success on the Westinghouse locomotives now in service on the Chicago, Milwaukee & St. Paul R. R., Paulista Railway and Chilean State Railways. Thirteen running notches are provided in each motor combination, which gives a wide speed range in regeneration to meet all train and grade conditions. Regeneration is controlled in a similar manner to motoring, except that after the engineman has chosen the speed or motor combination in which he desires to operate and has placed the motor combination handle and accelerating handle in their correct positions, the speed and braking effort are controlled by the regenerative handle.

The air and vacuum brake equipment consists of standard air brakes for the locomotive and vacuum brakes for the train. The locomotive brakes are controlled by an independent brake valve and also by the vacuum brake valve. The latter handles the locomotive air brakes, together with the vacuum train brakes in the same manner in which the automatic brake valve is employed on the standard locomotive and train air brake system. Compressed air for the air brakes and control is supplied by a motor-driven air compressor, and vacuum for the train brakes is maintained by two motor driven rotary exhausters.

The auxiliary equipment consists of a 3,000 volt motor-generator set which supplies low voltage power for control, lights, blowers, air compressor and exhausters and charges a floating storage battery which is carried as a reserve to operate an air compressor or exhauster in case of failure of line power.

Tables I and II give the more important ratings and dimensions. The ratings are on the basis of the A. I. E. E. rules.

Table I—General Data on Westinghouse-Baldwin-Naval locomotives:

Service	Freight and Passenger
Gauge	5′ 6″
Wheel Arrangement	0-6-0 + 0-6-0
Rigid Wheel Base	13′ 0″
Total Wheel Base	33′ 10″
Length over Buffers	46′ 4¼″
Total Height over Cab	12′ 3″
Total Height Panta. Locked Down	14′
Diameter of Drivers	39.37″
Total weight (short tons)	92.5
Weight on Drivers	18,500
Motors	Six No. 350-N-6
Gear Ratio	18.61

Table II—Ratings of Westinghouse-Baldwin-Naval Locomotives:

One Hour Ratings	
Horsepower	1,620
Tractive Effort in Pounds	28,000
Speed in H.P.H.	21.7
Continuous Ratings	
Horsepower	1,340
Tractive Effort in Pounds	21,280
Speed in M.P.H.	23.6
Tractive Effort at 25% Adhesion	46,250 lb.
Maximum Safe Speed	52 M.P.H.

Engine or Traction Sand

Sand is one of the most useful and, fortunately, one of the most common mineral commodities, says W. M. Wiegel, Mineral Technologist of the Bureau of Mines in a recent report of his investigations. By far the largest portion of the production is used in construction, including all forms of building, concrete and paving. Sand for this purpose is produced in every State in appreciable amounts. Excluding sand used for railroad ballast, molding sand stands next in tonnage produced, followed by glass sand.

In addition to the above, many grades of sands, with special characteristics, are used in industrial processes, and may be classed in a group as "special sands." This includes filter sand, sand blast sand, engine sand, abrasive sand, fire or furnace sand, etc.

Very few sand companies depend upon the production of any one of the grades, as their source of revenue. They are generally especially prepared from the bank run of sand by different methods of screening or washing, or may, in some instances, be by-products from the production of other grades. Many companies not now producing them might be able to supply local demands by a slight addition to their plant. In nearly all cases, they command a better price than the usual grades of building sand.

Engine sand, or traction sand, as it is sometimes called, is used to prevent the slipping of the driving wheels of locomotives, or other self-propelled vehicles, on wet or slippery rails. Its greatest use is, of course, for railroad locomotives, but street cars use considerable amounts and mine locomotives require its use. As the sand must be very dry when used, most consumers have their own drying equipment, so it is often shipped damp, with its natural water content or that resulting from washing by the producer. It must be fairly fine and free from rubbish, leaves, small sticks, or large grains of sand or pebbles that would tend to choke the feed pipes and valves leading from the sand box to the rail. On the other hand, it should contain a minimum amount of dust and very fine particles, which tend to retain or absorb moisture and form lumps. A sand containing clay is unsuitable, as the grains are immediately crushed to a fine powder under the drivers; a fine pulverized silica would give the necessary tractive effect, but such a material would not flow through the feed pipes. Either a rounded or angular grained sand is suitable, except that very rounded grains are more inclined to roll off the rail before being caught under the drivers and be wasted.

The Pennsylvania Railroad System does not have a definite speicfication for engine sand, but states that it should be high grade, over 95 per cent silica, comparatively free from foreign particles, non-caking and have sharp, clean grains of such size that approximately all will pass a 20 mesh and be retained on an 80 mesh sieve. Examination of the various sands used for locomotive sanding purposes are regularly made by the Test Department at Altoona, Pa.

The Southern Railway System also do not buy their en-engine sand to specifications, but test sand from new sources and compare it with sand used that has given satisfactory results. They use as a standard an available sand on their line, which is a quartz sand, practically free from loam and with the following approximate screen analysis:

All through No. 10 and held on No. 40 sieve.......40%
Through No. 40 and held on No. 40 sieve.........55%
Passing No. 80 sieve........................... 5%

The Chicago, Ottawa & Peoria Railway (Electric) tried to use a sand from their own pit, but it had a natural bonding property, and also would absorb moisture in damp weather, probably due to the presence of vegetable matter. Its use was abandoned and washed and dried silica sand produced at Ottawa, Illinois, is now purchased. Although the grains are decidedly rounded, the sand gives satisfactory service.

The United Railways Co., of St. Louis, use Mississippi River sand after drying and screening through 3/16 inch mesh wire cloth. The excavation from the river, followed by overflow from the barges, gives it a partial washing that removes most of the silt.

The Washington, D. C., street railways and some of the railroads in the vicinity use washed Potomac River sand that is coarser than the ordinary. The screen analysis of a sample is as follows:

Passing 6 mesh	100.0%
Retained on 8 mesh	1.5%
Retained on 20 mesh	21.1%
Retained on 65 mesh	89.6%
Retained on 100 mesh	95.8%
Retained on 200 mesh	99.5%

All engine sands are screened to remove foreign material and oversize grain. In addition, most of them are washed, which is sufficient to remove the excess fines. Some engine sand is the screenings removed from sand blast sand. The original sand has been double washed, so nearly all dust and fines have been removed. A New Jersey plant markets some of its screenings from sand blast sand as engine sand. This is also a washed product. At St. Louis, the pumping of the river sand into barges permits the overflow of clay, silt and a large part of the fines. The wet sand is then hauled in railroad cars to the drying plant and dumped in concrete bins. These feed to a conveyor, delivering to a 4 feet by 20 feet rotary, direct heat drier. Moisture content of the wet sand was 3¼ per cent. The capacity of the drier was 12 tons per hour, with a coal consumption of 1 ton per 73 tons of sand. The dried sand was screened over a 3/16 inch wire mesh on a rotary screen.

Considerable difference of opinion exists as to the relative merits of round grained and angular grained sand. The fact remains that both kinds are used for all purposes and doing the work required of them. So it is believed that, if prepared with equal care to the same specifications, there is little difference in their performance, if the grains are equally tough. It must be said, however, that, while the individual grains of most of the rounded sands are tough and free from flaws and microscopic cracks, a few of the angular grained sands have grains which break down more readily under impact, or shear, and hence are consumed, or "wear out" more rapidly.

Northern Pacific Men Form Association

Employees of the Northern Pacific Railway have formed "The Veterans' Association of the Northern Pacific" to perpetuate the old friendships, promote measures for the best interests of the employees and develop the historical record of the pioneer railroad of the Northwest. Enrollment of members is in progress at each of the twelve division superintendents' offices, at the offices of the four shop superintendents, and at off-line representatives' offices throughout the United States. Any employee who has served the Northern Pacific in any capacity for thirty years or more is eligible to membership.

The charter roll will remain open throughout the system until January 1.

A Fordized Train

The steamer was south bound off the coast of Chile, in the latter part of August, and the feeling of spring was in the evening air, when the steward came to a group of passengers and said that they were approaching the port of Arica, Chile, and that about 75 miles inland, across a desert country there was an interesting Indian Village, called Tacna. That if there were fifteen people who would like to go out there, he could send a wireless message ahead and arrange for a special train to take them out there.

The quota was quickly filled and much wonderment was expressed as to what sort of a special train could be had for fifteen passengers for a run on one hundred and fifty miles for $37.50 or $2.50 apiece.

The train with two of its passengers is shown in the illustration. It consisted of an old Ford touring car, with

Ford Touring Car Train

an extra gasoline tank on the hood. The original wheels had been removed, and in their place ordinary pressed steel wheels, such as are used on hand cars, were substituted.

Instead of the pivotted steering wheels at the front a rigid axle was used, while at the rear no change was made other than the change of wheels. Other than this the Ford motor was in the same condition as when it left the factory at Detroit, even the steering wheel being left in place with its throttle and spark levers in place. The mechanical connection to the wheels alone having been disconnected.

The car, as will be seen, was a little box, carried on four of the pressed steel hand car wheels, and with a spring suspension that was not what could be called the acme of ease and comfort, especially when running at a speed of 30 miles an hour, at which it was hauled when the little motor had settled down to its work.

The seats were arranged across the car in the usual way, so that an ample opportunity was afforded to see the country.

As to the efficiency in performing its service nothing more could be asked, and as for first cost it is probably one of the cheapest trains in the world, and having seen it and ridden on it, the reason why it could be run for one hundred and fifty miles for $37.50 is readily understood.

The Development of the Cast Iron Car Wheel

An Outline of Some of the Outstanding Features in the Production of the Present Day Wheel

By GEO. L. FOWLER

The fact that there was available, in the United States, a good iron, capable of being chilled to extreme hardness, from which a cheap and strong car wheel could be made, probably contributed as much as any other single item to the rapid growth of American railroads.

Until the seventies of the last century the cast iron wheel was in universal use under all of the freight and passenger cars of the country, and it is still in use under the great majority of the freight cars, it having only been supplanted by the steel wheel, under cars of high capacity.

The car wheel, as made for the past seventy years or more is formed of a heavy hub that is pressed upon the axle by an hydraulic press. From the front and back portions of the hub two plates extend out towards the rim. These plates come together to form a single one just before the rim is reached into which it runs. This single plate is strengthened by curved ribs at the back. The rim consists of a soft gray iron portion towards the center and a hard or chilled tread and flange. This tread is exceedingly hard and the metal of which it is composed extends from the outer rim to the crest of the flange by which the wheel is kept on the track.

It is a pecularity of the iron used in the manufacture of car wheels that when it is suddenly cooled upon being poured into the mould the contained carbon goes into the combined form and makes the metal exceedingly hard. This hard metal is made to form the tread or wearing portion of the wheel.

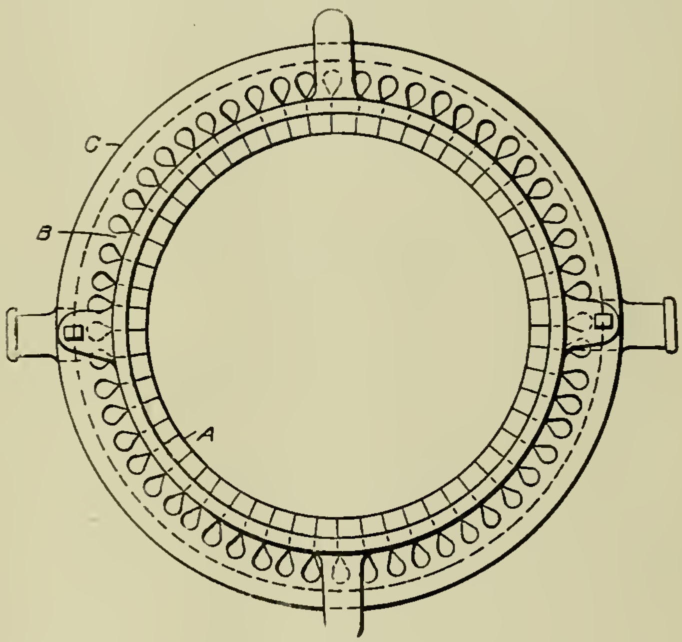
The method used to effect this sudden cooling is to form the tread and flange portion of the mould with a smooth ring of cast iron. When the hot metal comes in contact with the ring it is suddenly cooled or chilled and this quick solidfication makes the metal exceedingly hard.

In the case of the first cast iron wheels that were made, the tread was not hard enough to give a satisfactory service. This led to the development of the chill for which a patent was issued to Phineas Davis of Baltimore on July 29, 1834. The chill, as there described, consisted "of a hoop, or ring, of wrought iron, made and placed in the flask, or mould, at the time of casting." Later on a cast iron matrix was used and has been continued until the present time.

There are two general forms of chills used. One is a plain smooth ring bored out to form the matrix for the tread and flange of the wheel. It is from 3 in. to 4 in. thick. The other type is known as a contracting chill and a number of designs have been used most of which have been patented. The object of the *contracting* chill is to so construct it that, when the moulten metal is poured into it, the inner surface will contract and become of smaller diameter, thus following up and remaining in contact with the shrinking metal of the cooling wheel. It will be understood that, with the plain ring chill, this does not occur, for, as soon as the moulten metal strikes it, it becomes heated and expands and thus moves *away* from the shrinking metal of the wheel instead of towards it.

One of the simplest forms of contracting chills in use is that shown in the accompanying illustration. In this the inner portion *A* is turned to form the matrix for the tread and flange in exactly the same way as the solid ring chill. But instead of being a solid ring it is cut into a large number of small sections, each of which is connected by a bar *B* with the outer ring *C*. Sometimes this outer ring is hollow and a stream of cold water is made to circulate through it. Sometimes it is solid. The action of the chill is this: When the hot metal touches the sections *A* they are heated and with them a part of the bars *B*. This heat causes the usual expansion of the metal. But as the outer ring *C* is removed from the influence of the hot metal, it retains its original temperature and dimensions. The expansions of the parts *A* and *B*, therefore, causes *A* to move in towards the center, thus reducing the diameter of the chilling surface and tending to hold the chill in contact with the shrinking metal of the wheel.

It is the securing of a combination of a hard chill with a strong gray iron that is the essential feature in the selection of the irons that are to be melted and cast into car wheels.



Whitney Contracting Chill

All during the early years of car wheel manufacturing charcoal pig iron was considered the only suitable material from which a wheel could be made. But, at present, coke irons, that is irons melted in a furnace burning coke instead of charcoal are extensively used and it depends more on the location of the foundry and the irons available as to what shall be used than upon the class of iron, charcoal or coke.

The object of using a charcoal iron was that it was freer from sulphur and phosphorus than the coke irons, because of the entire absence of their impurities from charcoal. But when it is considered that the melting in the cupola for the manufacture of wheels is done with coke, and that the iron flowing from it is essentially a coke iron the supposed advantages of charging with a charcoal iron disappear.

The method of handling, selecting and charging the iron into the cupola has also undergone marked changes from that originally used. Until recent years the mixture of irons charged into the cupola was made entirely by a selection of certain brands that had been found by experience to give good results. There was some inspection of course. The usual method would be to break a few pigs out of each car load and examine the fracture. If the fractures ran with some uniformity as to appearance, the carload was accepted as being all of the same character. But, if there was variations the inspection was continued. It was on the basis of the appearance of the fracture and strength that the final choice was made, and then, if a new iron was under consideration, a few wheels were made. If these came up to the requirements as to strength and depth of chill, others were made and put into service.

It must not be supposed, from this, that satisfactory wheels could be made from any accepted brand, for it was found that better results could be obtained from a mixing of brands than from the exclusive use of any one kind. The whole structure, therefore, rested on observation and experience and not upon chemical analysis, so that the success of an industry often depended upon the practical knowledge and experience of a single individual.

This method has now been changed and the selections of irons for car wheels is put upon the basis of a chemical analysis of the irons used, and the testing and inspection of car wheels is more exacting and rigid than formerly.

Among the tests to which wheels are subjected is one known as the thermal test. It is well known that among the most destructive agencies at work upon a wheel in service is that of the brakeshoe. This heats the rim and sets up excessive internal stresses, that are apt to crack it. In order to determine as to whether the wheel has the strength to withstand these stresses or not the thermal test is applied by which the rim is heated while the balance of the wheel remains cool and undisturbed.

This, together with the rigid drop test by which the strength of the wheel is determined, requires greater care and certainty than formerly in the selection of the metal used. This selection is now made by chemical analysis, and a chemical analysis of the finished product is looked to to determine the quality of the wheel.

It is well known though sulphur and manganese have a hardening effect on cast iron, the silicon is really the controlling element in the formation of the chill. If the silicon is too high, say above .80 or .90 per cent, the iron will not chill. It is, therefore, necessary that low silicon irons should be used for cast wheels. This may be called a basic principle, and is one of the reasons why charcoal irons were so extensively used. They were low in silicon. Now when it was learned that low silicon was essential, a percentage of steel rails was added to the mixture. This was the subject of a patent issued to William G. Hamilton in 1868 and was somewhat extensively applied for a number of years, the most pronounced and consistent use having been made by the Altoona foundry of the Pennsylvania Railroad.

In his patent, after stating that the cast metal of chilled wheels was lacking in the requisite tensile strength, Mr. Hamilton said that he had found, "by experiment, that a mixture of steel, low steel, or sponge steel, made direct from the ore, and cast iron, preferably of about equal parts, but which may be changed, according to circumstances, produces, when melted, either together or separately, and mixed in a molten state, a compound which, when cast in chill moulds in the ordinary manner for producing cast iron wheels, will chill in the tread and form a smooth homogeneous casting, having the quality of resistance to tensile strain in a higher degree than any compound of metal heretofore known which can be cast at a temperature sufficiently low to chill."

This claimed advantage was not, however, generally conceded, especially as the specifications of the Hamilton patent, of mixing the steel and cast iron in equal proportions was not followed in practice, where but 10 per cent, by weight, of the steel rail was used, and this a ladle addition. But instead, it was the opinion of the foundrymen not that the steel of the rail would, of itself, add anything to the strength of the wheel, but because the low silicon, needed for the wheel, could be obtained by mixing a pure iron free of that element with the pig metal, and the purest metal available is steel, and the cheapest form in which it is available is an old rail; hence old rails were used solely for the purpose of reducing the percentage of silicon content in metal where it would otherwise be too high.

Hence in making up a charge, it is the content of silicon and manganese that is especially watched. The practice in this regard varies with different foundries, and sometimes it is the silicon and combined carbon that receives the major portion of the attention. The reason why the combined carbon can be disregarded is that it is a rather difficult element to control, that it is influenced by the sulphur and that it is quite capable of taking care of itself. But the softening effect of silicon makes it necessary that it should be very carefully watched, while the hardening effect of manganese, or even of its absence, in the extreme, makes it necessary that it should be confined to rather narrow limits.

The effect of the passage of the metal through the cupola is to lower the silicon by about .10 per cent and to raise the total carbon by about the same amount, hence, in making up the mixture for a heat it is done so that the silicon will be about .10 per cent higher and the carbon about .10 per cent lower than desired.

The desired analysis of the finished wheel may be placed about as follows:

Silicon	From .55 to .70	per cent
Manganese	" .45 " .52	" "
Phosphorus	" .28 " .33	" "
Sulphur	Not above .17	" "

That this result may be reached, it is desirable to know the composition of all of the iron used. This can be done for the pig metal, but that of the scrap has to be estimated.

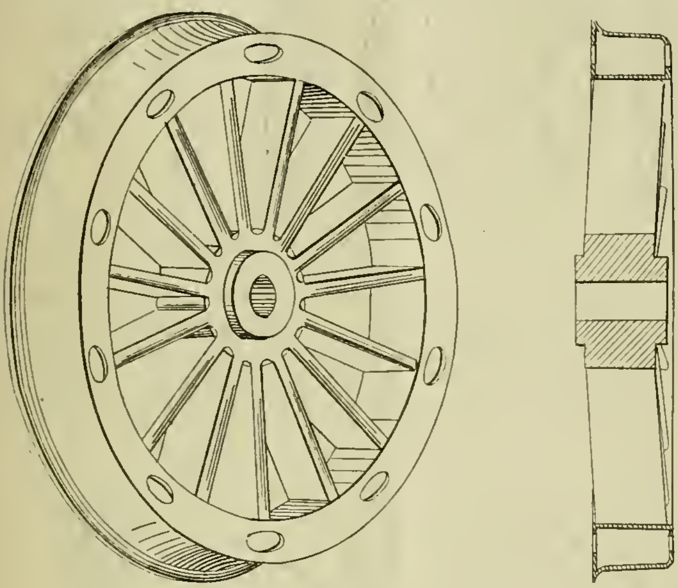
In the melting the quality of the coke used is of almost as much importance as that of the iron. The usual specifications call for what is known as 72 hour coke, and that it must be low in sulphur, and it must be strong enough to carry the burden or load of coke and coal above it in the cupola. The coke that is most highly esteemed in the United States is that made at Connellsville, Penna., though a coke of almost equal excellence is made from the coal of the celebrated Pocahontas vein in West Virginia. An analysis of a good melting coke would show it to contain an average of:

	Per Cent
Moisture	.09
Volatile matter	1.00
Fixed carbon	93.20
Ash	4.95
Sulphur	.71
Phosphorus	.05
	100.00

Such a coke, with a good blast and proper attention, will melt about 10 lbs. of iron per pound of fuel, the actual output varying with the pressure of the blast and other elements.

With the iron melted the foundry man is between the devil and the deep sea in the matter of pouring. For wheel work the iron must be melted hot, and yet while hot pouring adds to the ability of the wheel to withstand the thermal test, it is the dull metal that best sustains the drop test.

During the whole process of pouring the quality of the metal is carefully watched and samples are taken from the ladles at frequent intervals and poured against chilled blocks and broken. The depth of chill obtained in this way serves as a guide as to the quality of the metal and the depth of chill that will be obtained in the wheel and the proper conditions will be secured by the addition of ferro manganese, ferro silicon or old rails to the ladle. Ferro titanium has also been used in the ladle for the removal of slag and other impurities from the body of the metal. This is a cleanser and has no other effect. Then,



H. R. Dunham, 1838

too, in the melting, limestone is sometimes added to the cupola to soften the slag and make it more fluid.

While the foundry practice has been carefully developed, it is the form of the car wheel that has been given the major portion of the attention.

It was found at a very early date that the form of the section of the wheel was a controlling element in its efficiency. The shrinkage strains set up by the cooling of the metal, are apt to cause cracking unless provided for by the shape and thickness of the casting.

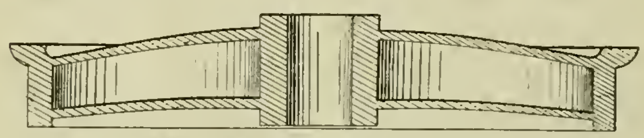
Following the pattern set by the wagon wheel, spokes were used in the early wheels for cars and many of the early designs were of that character. But the car wheel presented a class of problems that did not exist in the wagon wheel, and as early as 1829 the patent office was issuing protection to inventors for the betterment of the railway wheel. One of the first was James Wright, who patented the conical tread in 1829 for the purpose of compensating for the unequal length of the two rails on a curve.

Various composite forms of wheels were patented, and among the inventors of this type we find M. W. Baldwin, the founder of the Baldwin Locomotive Works.

In 1838 H. R. Dunham conceived the idea that it was bad practice to partly anneal the chilled tread of a wheel by having a body of unchilled metal beneath it, and designed a wheel with a hollow rim, by which the outer or chilled portion was supported only at the edges. It is needless to say that such a wheel could not stand up to the exigencies of railroad service.

In 1838 a patent was issued to Samuel Truscott, George Wolf and James Dougherty for a double plate car wheel, similar to that advocated by Prof. Sproule of McGill University, before the Engineering Institute of Canada about a year ago.

Here we have attention called directly to the trouble of cracking caused by the shrinkage of the metal in cooling. Instead of using spokes these wheels were cast "with two parallel or nearly parallel plates," which were "convex on one side and concave on the other" and which, in consequence of this peculiar form, "contract in cooling without danger of fracture, and without it being necessary



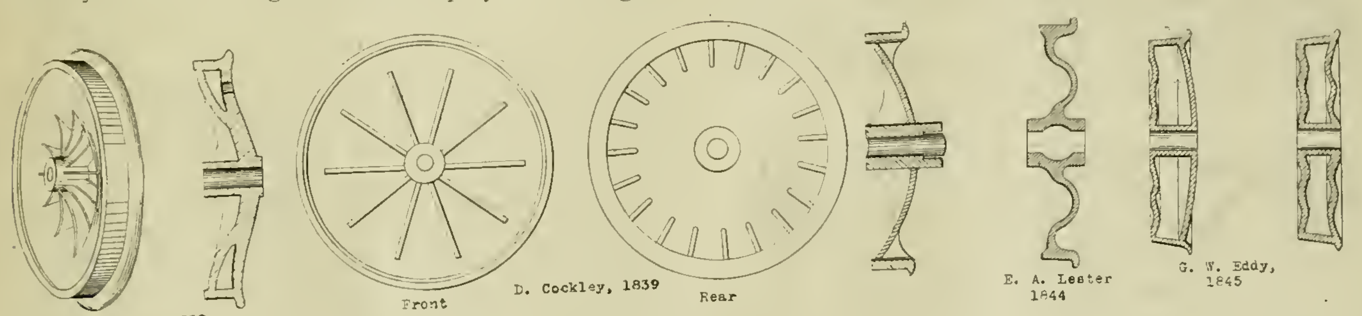
Truscott, Wolf and Dougherty, 1838

to divide the hub, as is done when car wheels are cast with spokes." It being claimed that the only effect of the contraction was to flatten the two plates in a slight degree.

But this double plate arrangement did not quite solve the problem of shrinkage cracking and there followed a series of other designs intended to accomplish that purpose.

In 1839 Wm. M. Pennell made an approach to the present section, except that he reversed the design. Instead of having the double plate rise from the hub, with a single plate and brackets beneath the rim, he turned it about and dropped the double plate down from the rim, and supported the single plate by brackets radiating from the hub.

In the same year D. Cockley tried to solve the difficulty with a deeply dished single-plate wheel, with brackets on the opposite sides of the same, thus supporting the plate from the hub and carrying the rim.

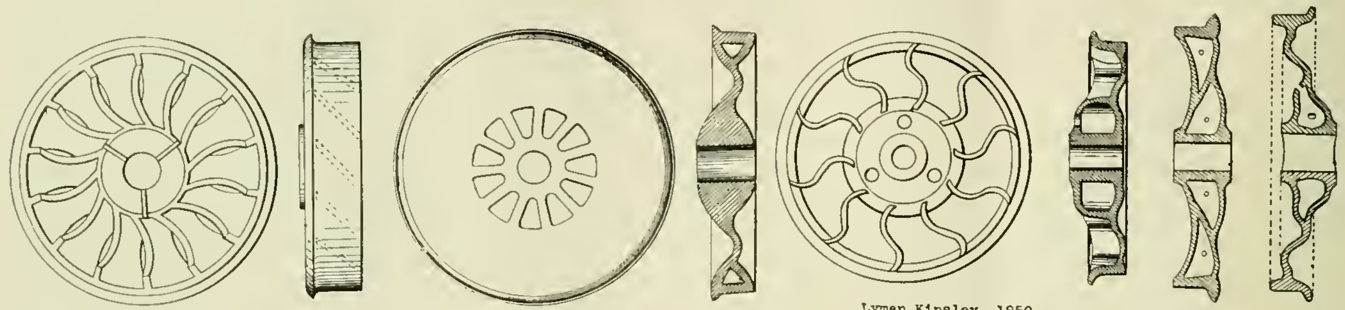


W. W. Pennell, 1839 — D. Cockley, 1839, Front, Rear — E. A. Lester 1844 — G. W. Eddy, 1845

None of these quite meeting with the requirements, E. A. Lester, in 1844, boldly discarded the brackets and the double plate, and patented a single corrugated plate wheel. It being supposed that the corrugation would give such flexibility to the web that it could yield to the shrinkage stresses and not crack. He was followed, as we shall see, by others who made slight variations in his design in order to reach the goal.

Closely following on his heels came George W. Eddy, who, in 1845, returned to the double plate form of Truscott, Wolf and Dougherty, and tried to overcome the cracking of those plates by corrugating one or both of them.

None of these designs being able to meet the requirements there came a return to the spoke wheel with spokes of a multitude of designs, and all intended to permit shrinkage without cracking; an example of which is given by the Small wheel of 1846, where the spokes were of a twisted form and set diagonally on the rim.

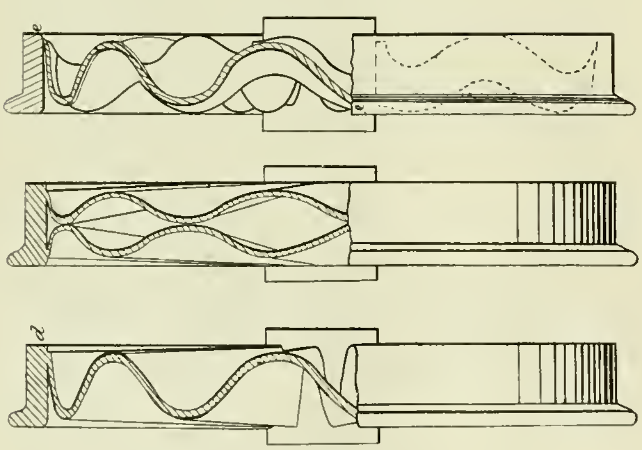


Alexander Small, 1846 James N. Cook, 1849 Lyman Kinsley, 1850 John Henry 1854 C. W. Swett, 1879

In 1847 Asa Whitney tried to beat these shrinkage strains by making double and single-plate wheels having both radial and circumferential corrugations, on the principal that no matter in what direction the shrinkage acted there would be a corrugation there to meet and yield to it.

J. M. Cook, in 1849, made a very close approach to our present form of wheel. The outside contour of the wheel next the hub is what we now use, but instead of making it in two plates, he neglected to provide a core, and made it in solid spokes which was, undoubtedly, his undoing.

Lyman Kinsley on March 12, 1850, came nearer; but he gave his inside plate a right-angled bend with a flat top and brought the flange-supporting brackets down



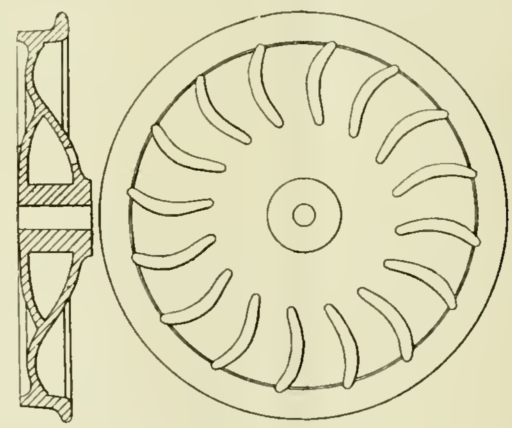
Asa Whitney, 1847

against it in such a way as to make the structure so rigid that it cracked.

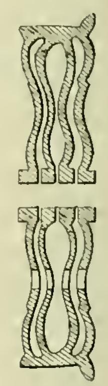
At last, on October 8, 1850, Nathan Washburn hit upon the form of section that seems to have solved the problem not only of the casting of the cast iron wheel, but of making one of sufficient strength to meet the requirements of railway service, and it is this 1850 form with few modifications to meet the changing demands of the times, that is in use under thousands of cars as the standard wheel of the present day.

It is well known that, while Washburn brought out a design that was generally efficient the trouble with cracking was not entirely eliminated at the first trial. This state of affairs led to numberless improvements (?) in the form of the section of the wheel. There was, for example, the double plate modification of the Washburn section, of John Henry in 1854, and Swett wheel of 1879 in which all of the plates were corrugated. Then there was a multitude of freak designs such as the four-plate, corrugated wheel of Spafford in 1860. Of course the majority of such designs never reached even the dignity of a trial.

Two serious attempts were made to develop the single-plate wheel after the Washburn design had been brought out. One was that of Ross, in 1857, who attempted to stiffen his corrugated plate by brackets dropping down from the rim and rising from the hub, but the cracking was not stopped. The other was that of Bosworth, whose



Nathan Washburn, 1850



W. W. Spafford 1860

patent was dated in 1860. In this design the sole dependence for strength was placed upon the corrugated plate. There were no brackets and the plate ran from the center of the hub to the center of the rim.

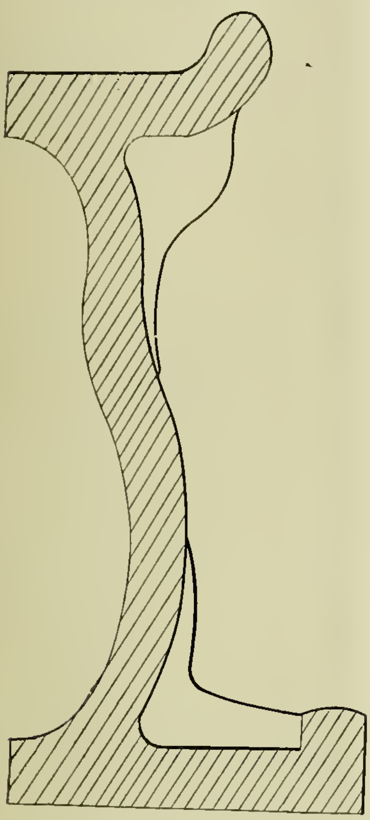
As late as 1877, when the original Bosworth patents had expired, a serious attempt was made by a well-known wheel foundry to exploit this wheel and place it upon the market. As far as the foundry practice was concerned the single-plate corrugated plate seemed to meet the requirements of compensation for shrinking while cooling; but, when placed in service, the plate did not have the strength sufficient to withstand the lateral thrusts of the wheel against the rail. The result was that cracks were soon developed and the wheel was found to be unsuited to the service and its manufacturing was stopped.

For more than thirty years after the appearance of the Washburn design, foundrymen were busy trying to perfect it, and patent after patent was issued to cover details that, it was hoped, would cure the ills that cast iron wheels seemed to be heir to.

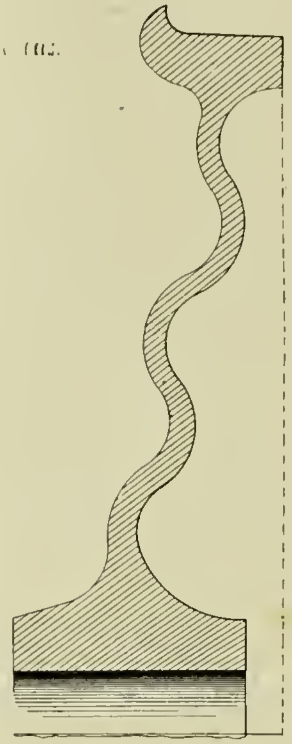
During all these years the believers in the double-plate wheel were not idle and if it were possible to make such a wheel that would meet the requirements of the foundry and the service, some one of the great number of designs, that were patented, would surely have done so. But they all went the way of the unfit and there is no survivor of the great effort expended upon them.

And this is not all. The records are filled with descriptions of composite wheels, in which the rim and hub were separate pieces held together by bolts, rivets or clamps.

And finally with a name that is legion come the freak designs. Designs that bear every evidence of having



James M. Ross, 1857



Geo. S. Bosworth, 1860

emanated from the brains of men who knew nothing about car wheels, but who having heard that an improvement was needed proceeded to make it, after the pathetic manner of the farmer's boy who was afterwards responsible for so many automatic couplers.

A lapse of more than twenty years intervened between the earliest cast iron wheel patent and the appearance of the Washburn design, and since then hundreds of car wheel patents have been issued, but it has held its own and is the standard form of the country, and is likely to so remain despite any spasmodic attacks that may be made upon it. And it speaks well not only for the material but the design, that without any material change except in weight, it has met the requirements of the foundry and service on cars that have risen four and five-fold in capacity.

The cast iron wheel stands, therefore, as a distinctive feature of American practice, and without it the development of the railroads of the country would have been placed under a serious handicap.

Castleton Cut-Off of the New York Central

The Castleton cut-off of the New York Central which was constructed at a cost of $25,000,000 was formally opened for traffic on November 20th.

By means of the cut-off freight traffic over the six-track mainline of the New York Central Railroad between the great agricultural West and the busy industrial territory east of the Hudson River will be diverted from steep grades and congested trackage at Albany, and shunted across the cut-off over the Hudson ten miles below the capital city by easy gradients.

Beside the high bridge, which eliminates heavy grades both east and west of the low drawbridges at Albany, the cut-off includes 28 miles of new double-track railroad, a terminal freight classification yard, an engine terminal and other appurtenances that greatly increase the capacity of the whole railroad.

The conspicuous feature of the cut-off is the bridge across the Hudson, which is a mile long, including approaches, and 150 feet above the river. The bridge has been dedicated to the memory of the late President A. H. Smith. The improvement was originally conceived by him.

The bridge is a double-track, through truss-structure in two river spans of 600 and 400 feet, respectively, resting upon three stone and concrete piers. The east approach crosses over the present main line of the New York Central, which latter hugs the river shore and all the way between New York and Albany. This line will continue as the main artery for passenger traffic.

Increases Freight Capacity

The primary object of the cut-off was to abolish the "bottle-neck" at Albany which limited capacity and at periods of heavy density of traffic produced freight transit delays. It eliminates the most troublesome spot on the system, according to New Work Central officers.

Up to the present all traffic, both freight and passenger, between New York and Boston and the West has had to cross the Hudson on low drawbridges at Albany with sharp ascent from each side of the river. During the season of navigation these bridges are sometimes open as much as eight hours in twenty-four, or in extreme cases even ten hours in twenty-four. As trains come up to the drawbridges in an almost continuous procession, this has been a serious restriction, involving delays and congestion.

Moreover, the stiff grade westbound out of Albany and eastbound for trains destined for Boston required that heavy trains be subdivided at the expense of much switching and the sections boosted up the hills by "helper" locomotives, all of which has been costly and slow, requiring extra crews and equipment.

Further, it was impossible to find room in the hills west of Albany for the necessary yards and terminals required for the increasing volume of business. A move to a roomier route was imperative; but years of effort were required to overcome obstacles and secure the necessary authority to build from state and federal governments. The Hudson River Connecting Railroad Corporation, a New York Central subsidiary, was organized to construct the cut-off in 1913, but legislative obstructions prevented commencement of work until 1922.

At Selkirk, on the west shore of the Hudson, are established what are some of the most modern and efficient freight car terminal yards in the world. These yards mark the western terminus of the Connecting Railroad and are six miles long. They have a present capacity of 11,000 cars, which will eventually be increased to 20,000 cars. Movements of cars in the yards have been completely segregated into units handling eastbound and westbound business. Each unit has its own "hump" for gravity switching, the switches being electrically operated from towers.

The ceremonies in celebration of the opening of the new gateway, at which many nationally prominent men were present, were carried out under the joint auspices of the Chamber of Commerce of Albany and the New York Central.

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X-Ray Examination of Metals

The inspection of metals has been limited to an examination of their external appearance and an investigation to destruction of a sample that was supposed to represent the metal under inspection. This supposition has frequently been found to be a false one, resulting in the rejection of many pieces after an amount of expensive machine work had been done upon them.

Various devices, electric, magnetic and others have been designed and tried, all looking to a determination of the interior of metal that was beyond the range of vision and which could only be accurately learned by cutting. And even cutting cannot be depended upon to detect flaws and imperfections. If the tool cuts into a defect, well and good; but even if the finished surface is clean and unblemished, it is no guarantee that a dangerous flaw may not exist immediately beneath that surface.

At last the all searching eye of the X-ray has been utilized in this work and bids fair to become a thoroughly commercial proposition.

A very powerful apparatus has been installed at the Watertown, Massachusetts, arsenal where with a voltage of 200,000 impressed on a Coolidge tube photographs have been obtained of steel one inch thick in an exposure of one-minute; of two-inch thickness in five minutes and of three-inch in thirty minutes. For greater thicknesses the exposures have not yet been successful.

But for those thicknesses where a photograph has been obtainable it has been possible to detect occluded sand, cavities resulting from incomplete oxidation of the metal in the furnace, cavities formed by gases entering the metal during solidification, cracks caused by unyielding cores, welding and imperfections in welding and burnt-in metal.

The effect on the film is that where the X-ray passes through a defect, and therefore through less thickness of metal, it reaches the film with greater intensity and therefore forms a darker spot on the film, the outlines and size of the spot corresponding closely with those of the defect.

Colonel Dickson of the ordinance department who is in charge of the equipment is very sanguine that our knowledge of metals will be wonderfully increased by it.

According to existing laws the Watertown laboratories will make tests of iron and steel for any citizen at cost and the result is that the use so made has been very satisfactory. The field for the X-ray examination is almost unlimited, and is especially applicable where no flaws in the metal used are permissible for it will avoid the losses of expensive machining of pieces that must be discarded if such machining discloses any defects.

Annual Report of the I. C. C. for 1924

The Interstate Commerce Commission has just issued its thirty-eighth annual report to Congress, covering the period from November 1, 1923, to October 31, 1924. All phases of the Commission's activities and transportation developments of the past year are described in detail. Among the major subjects dealt with in the report are Earnings, Valuation, Recovery of Excess Earnings, Progress of the Industry in Its Public Aspects, Rates, and Freight Movement. In reporting on these subjects the Commission says in part:

New railroad construction is not keeping pace with abandonments, although existing roads are constantly being improved by additional main tracks and yard tracks and sidings.

The substitution of larger cars and locomotives for retired equipment continues. From 1908 to 1923 the average tractive power of a locomotive increased from 26,356 pounds to 38,835 pounds and the average capacity of a freight car from 34.9 tons to 43.7 tons.

The calendar year 1923 marks the peak of railroad freight tonnage and ton-mileage.

The number of passengers carried in 1923 although larger than in the year preceding, was smaller than in 1913, 1914, 1916, and in each subsequent year, including 1921, but this relationship does not hold true of the passenger-miles because of the increase in the length of the average journey.

The growth in the length of haul per ton of freight reached its maximum in the year 1919, having been 309 miles in that year as compared with 300 miles in 1923 and 254 miles in 1908 (fiscal year).

The investment per mile of road continues to grow annually, but the rate of return from operations on the reported book value, which now exceeds 21 billions of dollars, shows wide fluctuations. That for 1923, 4.56 per cent, was the most favorable since 1917. Likewise, the net income after paying fixed charges, both in absolute amount and in ratio to capital stock, 7.06 per cent, was the largest since 1917.

For the year 1923, 62 per cent of the capital stock paid dividends, the average rate on such stock being 7.29 per cent. But if the amount of dividends is spread over all the outstanding stock, the average percentage falls to 4.52.

In 1923, as in 1920, operating revenues passed the 6-billion-dollar mark. While operating revenues were greater in 1923 than in 1920, operating expenses were nearly a billion dollars less than those of 1920. Maintenance of equipment expenses continue to absorb a much larger proportion of operating revenues than they did 15 years ago.

The average number of persons employed in 1923 by Class I steam roads was 1,855,260, representing a substantial reduction from the peak in 1920, 2,022,832, but an increase over the figures for 1921 and 1922. The compensation to employes was $3,004,083,599. This sum bears about the same relation to total operating expenses as obtained ten years before, but in relation to operating revenues the pay roll is a somewhat larger percentage than for 1913, although a decided reduction from the peak figure of 1920.

The average receipts per ton-mile in 1923 were 1.132 cents as compared with 0.729 cents in 1913, an increase of 55.3 per cent. In the same period, the passenger-mile receipts increased from 2.008 cents to 3.026 cents, an increase of 50.7 per cent.

Railroads to Expend $1,100,000,000 for Equipment and Improvement in 1925

Estimates made at the meeting of the Association of Railway Executives in New York on November 19, indicated that during 1925 the railroads will expend approximately $1,100,000,000 for new equipment and improvements in facilities, in addition to the $2,136,446,426 authorized during the last two years.

Executives, representing every important railroad in the country, attended the meeting.

The executives promised a campaign to improve the equipment and the service of the railroads on the same scale as in 1923 and 1924. They also directed attention to the expenditure of $1,077,297,000 for equipment and improvement in 1924, compared with $1,059,149,426 the previous year.

In a statement given out by Mr. Hale Holden, the retiring chairman, the platform of the railroads for the coming year was outlined as follows:

1. "That all railroad problems as they arise should be dealt with and settled as economic questions, which they are, and not as political issues, which they are not.

2. "That there is no condition existing today which calls for any urgent legislative action by Congress with respect to the railroads, either as to rates, labor relationship or valuation.

3. "That railroad freight rate and passenger fare adjustments should be left to the duly constituted Government regulating body, where they will receive a full and fair hearing and an adequate economic analysis, and not be made the subject of direct legislative action. Rate making by legislative action would be destructive.

4. "That amendments to the Transportation Act which may be demonstrated to be necessary by experience under normal business conditions should be made only after a fair and judicial consideration of all pertinent economic facts, and not as the result of political agitation or of political pressure upon Congress.

5. "That a continuation of adequate transportation facilities and service carries as an inevitable corollary the necessity for adequate revenues to be earned and retained in order that railroad credit may be restored and re-established in the confidence of investors and that ample additions, improvements and repairs may be made at reasonable financial costs.

6. "That the carriers should seek in every legitimate way to enlighten the public on all phases of the complex transportation industry by the dissemination of authoritative information and should foster and aid the tendency recently observed to remove railroad questions from the arena of politics to the field of economic analysis so that the private management of the railroad may continue a program of increasingly adequate and efficient service, under full and proper regulation, and may continue the efforts they are making to serve faithfully the public interest.

7. "And that, looking forward with continued confidence to the fairness of the American people, the railroads are determined to continue their policy of expansion to provide adequate transportation for the increasing commerce of the country and to strive in every way to bring about greater efficiency in operation and a progressive reduction in cost."

In support of the railroads' declaration of policies as given above, Mr. Holden made the following statement on behalf of the Association of Railway Executives:

During the past two years, the railroads of the United States have successfully handled without transportation difficulties the greatest freight traffic ever offered in any similar period of time in history.

By every valid test, railroad operation both in 1923 and 1924 has shown a marked increase in efficiency. To this increase in efficiency, valuable contributions have been made by railroad employes and by cooperation of shippers. In view of the increased efficiency in operation during both years, and in view of the record-breaking traffic handled, it would fairly be presumed that financial returns would appear commensurate with the character and quantity of service. As a matter of fact, however, the railroads of the country again fell far short of realizing the fair rate of return contemplated under the terms of the Transportation Act.

A Locomotive Christening

It is not often that a locomotive is formally christened by the breaking of a bottle of champagne on its pilot after the manner of sending a ship to its home on the water. Such an event, the second of which we have a record, occurred in the yards of the Colonie shops of the Delaware & Hudson Co., at Watervliet, N. Y., on the afternoon of Thursday, December 4.

The occasion was that of the formal entry into the service of the company of locomotive No. 1400. The christening was performed in the presence of a large gathering of railroad men and other interested parties, by Mrs. Harleston Corbett Lewis, the granddaughter of Horatio Allen, who brought the famous locomotive the Stourbridge Lion to this country and the name she bestowed upon this new contestant for locomotive honors was that of her distinglished grandfather.

Horatio Allen was born in Schenectady, New York, in 1802. He entered the service of the Delaware & Hudson Canal Co. in 1825 and was selected by the company as its agent to purchase locomotives and railroad iron in England; and in January, 1828, proceeded to that country to execute his commission.

He purchased four locomotives, one of which, the Stourbridge Lion, has become famous as being the first locomotive to run upon a railroad track in the western hemisphere. After leaving the service of the company he occupied many positions of prominence and died on December 31, 1889, at the age of eighty-seven years.

The "Lion" arrived in New York, May 13, 1829, and was shipped to Honesdale, Penna. by water, arriving at its destination the latter part of July. On August 8, 1829, with Horatio Allen as engineer, the "Lion" made its famous trip for a distance of about three miles from

Honesdale and return, proving the feasibility of this type of motive power.

The new Horatio Allen which furnished the occasion of the christening, was designed by Mr. John E. Muhlfeld, consulting engineer for the Delaware & Hudson Co. and was built at the Schenectady works of the American Locomotive Co. this year and marks a decided departure in many respects from the conventional locomotive. It is fitted with a water tube firebox, and carries a steam pressure of 350 lbs. per sq. in. It has a cross compound arrangement of cylinders and many other novel features which will be fully illustrated and described in a future issue of this paper.

Immediately after the ceremony a luncheon was served to the guests and on the menu there was printed the following comparisons between the Stourbridge Lion of 1829 and the Horatio Allen of 1924.

	THE STOURBRIDGE LION		THE HORATIO ALLEN
Height to top of stack	15′ 0″		15′ 0″
Wheel Base	(About) 4′ 6″	Engine	29′ 0″
		Engine and Tender	65′ 7¾″
Weight—working order	16000 Lbs.	Engine	348000 Lbs.
		Engine and Tender	545800 Lbs.
Cylinders	Dia. 8¾″	High Pressure	23½ x 30″
	Stroke 36″	Low Pressure	41 x 30″
Drivers-Diameter	48″		57″
Tractive Power	1750-2000 Lbs.	Simple	84300 Lbs.
		Compound	70300 Lbs.
		+ Booster	19700 Lbs. added
Heating Surface	68-75 Sq. Ft.		3200 Sq. Ft.
Water Capacity-Tender	100 Gals.		9000 Gals.

From which it appears that the only measurement that the two engines had in common was the height of the stack.

The speakers at the close of the luncheon were introduced by Col. J. T. Loree the vice-president and general manager of the company, and the first to speak was Mr. L. F. Loree the president and chairman of the board.

Mr. Loree opened his address by calling attention to the very brief interval of time that had elapsed since this first locomotive had been run through the woods of Pennsylvania to the present, the whole of which was spanned by the lives of three generations. He reviewed the early history of rail transportation and emphasized the struggle that had taken place and is still taking place betwen what he called the rope haulage system and the independent unit system of transportation.

He spoke of the introduction of electric transportation in 1884 and characterized it as a modification of the rope haulage system and touched upon the introduction of the internal combustion engine to road vehicles. There is a possibility, too, that even to-morrow a cheap durable and fool-proof electric storage battery may be invented, enabling the use of its power by an independent unit in transportation, completing the discomfiture of the rope-haulage trolley car.

While this contest may be expected to continue long in the future, perhaps usurping and stabilizing itself in restricted fields, the dominance in its larger aspect will depend largely upon the ability, genius, courage and tenacity of the exponents of one or the other method of transportation. He said I have an abiding faith that for the main purposes of the railroad—the transportation over long distances of heavy articles—the unit system of transportation will be the dominant one.

The engine which has today been christened the "Horatio Allen," in honor of the man who ran the first locomotive on the western hemisphere, is a step in the direction of insuring this position. The familiar self-contained type of multi-tubular boiler for steam locomotives, in combination with the superheater, has been retained. Instead of the usual water leg firebox with its undesirable flat sheets and staybolts, and the sluggish circulation of water, the firebox of the "Horatio Allen" has been built up of self-supporting cylindrical structures. These are in the form of drums and tubes disposed horizontally and disposed vertically, requiring no stays, which are directly exposed to the furnace heat and which not only "split up" the boiler water into small streams but also provide for its rapid circulation, thereby enabling quick absorption of heat and release of the steam bubbles.

It is this new pressure of 350 pounds that will be carried by the "Horatio Allen"; and it is the economy of producing additional power by raising the pressure of the steam that this locomotive will realize.

To make this possible, the pressure-containing parts of the boiler, superheater, cylinders, piping and other connections have been correspondingly strengthened. In fact, a higher factor of safety has been used than is ordinarily provided.

In order to limit to the lowest terms the problems involved, we have taken the most popular of our consolidation locomotives. We have made no material changes other than those indicated, except that the steam is used twice, i. e., it is expanded in a high pressure cylinder on the right side, then exhausted into a receiver, and expanded a second time in the low pressure cylinder on the left side, before it is exhausted into the stack. By this means the steam is more fully utilized before it leaves the cylinders.

It is hoped that the "Horatio Allen" will develop one-third more haulage capacity, with one-third less consumption of fuel and water, than the corresponding Consolidation locomotive. If these results are realized they mark a substantial advance in the efficiency of the unit system of transportation. Notwithstanding the greater heat in the boiler, the precautions taken in lagging its head will, we believe, reduce the temperature to which the engine crew is exposed.

In the conditions of employment since the beginning of railroading, while the fireman has not been without benefit, there has, I think, inured to him a lesser proportion than to his associates. It is not the least of the merits of this design that for the same result his labor of coal handling will be lessened by more than one-third.

The "Horatio Allen" is today what the locomotive was when Zerah Colburn described it in the middle of the last century—a combination of three distinct arrangements. The source of power lies in the boiler and firebox; the cylinders, valves, pistons and the connections are the means by which the power is applied to produce motion within the machine; and the wheels, by means of their adhesion to the rails, enable the exertion of the tractive force, securing the locomotion of the machinery which impels them, and from their surplus power above what is necessary to move the locomotive alone, to haul also the great load behind it upon the rails.

The "Horatio Allen" epitomizes the relations of the three elements of that industrial organization which distinguishes our civilization from all that have preceded it. There have been many definitions of truth. The one that seems to me most adequate is that "truth is things seen in relation." Complex as are the relations of management, capital and labor in the wide expanse of industrial organization, I am confident that if we look steadily and clearly we can mark them out and define them. If we can see them, we shall see the truth and the truth shall make us free.

This locomotive is a creation of management. The conception of the plan is basic, fundamental; and it is the organization, energy and direction of management that have given it effect.

This locomotive is a depository of capital. It is a characteristic of wealth that its owners are in possession of real opportunities of consumption for speedy enjoyment, or of reservation for future enjoyment, or of employment for purposes of production. It is wealth that is reserved and applied to production under the direction of management that is generally called Capital, and this reservation demands on the part of the owner great sacrifice and force of character.

But the "Horatio Allen," fine an example as it is of the art, striking as it is in its combination of management and capital, is a dead thing except in the hands of labor. He who looks with discerning eye to the contribution of labor, will fix his attention not on the output of physical energy, which in comparison with the power of this giant machine is but a feeble emanation, but rather on qualities far more ennobling—the complete discipline, the cheerful devotion to duty, the service carried on under every adverse circumstance, whether in wind and storms of rain and snow, or in fog, in the blackness of night of the beauty of the day; the high intelligence brought to the safeguarding, as well as the handling, of the movements entrusted to the charge of the locomotive's crew.

Mr. Loree was followed by S. H. Huff, representing the Brotherhood of Locomotive Engineers; J. E. Muhlfeld, the designer of the locomotive; Timothy Shea, representing the Brotherhood of Locomotive Firemen and Enginemen; J. G. Blunt, representing the American Locomotive Co., and A. G. Pack, chief inspector of the Bureau of Locomotive Inspection of the Interstate Commerce Commission.

In his address, Mr. Muhlfeld gave an interesting resumé of the steps that had led to the designing of the Horatio Allen and of the advantages that it is expected will result from its work on the road. This will be used in connection with the description of the locomotive that will be published in a future issue of RAILWAY AND LOCOMOTIVE ENGINEERING.

Meanwhile, the locomotive will be put into service at once and by the time this paper is issued from the press will be engaged in justifying its existence by the haulage of tonnage freight.

Annealing Steel Castings and Its Importance to Consumers

Paper Presented by H. A. Neel, at the Convention of Electric Steel Founders' Research Group

If a piece of glass is broken and examined afterward, it will be seen that the surface of the fracture is of uniform appearance due to the fact that glass in changing from a hot liquid to a cold solid, does not change with respect to the relation of its various chemical components to each other.

If a piece of steel is fractured and examined, it will be perceived that the broken face exhibits the sparkling facets of the crystals of which it is composed. When steel passes from a liquid to a solid state its constituents no longer hold the same relation to each other. Instead of being an "amorphous" or formless mass, it is composed of crystals imbedded in a setting corresponding to the cement which holds concrete together. In well-made concrete, the pebbles will break in two before they will pull loose from their setting. Similarly in steel, rupture occurs through the crystals and not around them. The cement holding the crystals together is stronger than the crystals.

The problem of the steel maker is to so control the relation between the crystals and the cement that maximum physical properties result.

The size of the crystals formed, when steel cools from a liquid to a solid state, is dependent on the rate of speed at which cooling takes place. Rapid cooling in thin sections produces much finer crystals than slow cooling in heavy sections. It is possible, however, to break down the diversely crystallized structure of steel as cast and produce a uniform structure throughout the casting, at a temperature well below the melting point.

The temperature at which a change of structure can take place in steel, as cast by plants in the Electric Steel Founders' Research Group, is about 1400 degrees Fahrenheit, but if the termperature is carried up to 1650 degrees F., the change is accomplished much more rapidly.

After the above rather elementary explanation, I will define annealing, as practiced by the five companies in the Research Group, to mean "heating of castings to a temperature between 1600 degrees F. and 1650 degrees F., and maintaining them at that temperature a sufficient length of time to insure maximum grain refinement."

Its importance in the estimation of the executives in these plants is indicated by the following clause in the Group Inspection Standards: "All castings except only such as are stipulated by the customer to be delivered to him in the raw or unannealed condition, shall be heat treated, as prescribed in paragraphs 27 to 31 inclusive."

Please note that annealing is not made contingent on the customer's request, but is obligatory in the absence of a request to the contrary. This is in line with our Group ideal that calls for the best castings we know how to produce. The benefits to steel castings from annealing are:

1. Increased physical properties.
2. Relief of strains set up in cooling and in welding operation.
3. Increased machinability.

Two things are of importance in considering physical properties, namely, strength and elasticity. The first determines the load that a given part will carry, and the second determines its ability to withstand shock. In practically all applications of cast steel, both properties are called into play. Annealing is carried on primarily to increase the elasticity or shock-resisting power of steel castings. The ultimate strength, or final failure point, is but slightly changed by ordinary annealing, but the working strength, or yield point, is materially increased in comparison with unannealed castings. Also the ductility, or ability to bend or stretch without breaking, is raised to 50% to 100%. Proper annealing is a guarantee to the customer that a given cross section of a casting will withstand a much greater amount of abuse than a similar section of an unannealed casting.

In changing from a hot liquid to a cold solid, steel shrinks one quarter inch per foot. This change in size results in cooling strains. The more complicated the design of the casting, and the more resistance offered to contraction by cores, etc., the greater will be the strains set up. Annealing, by returning the casting to a state of plasticity and subsequently cooling it at a uniform rate, eliminates such cooling strains and obviously decreases the likelihood of failure due to applying a load to a piece already in a state of internal tension. Every welding operation by heating a small part of a casting to the melting point while the balance remains cold, sets up strains similar to the original cooling strains. Hence, our inspection standards require annealing after any welding operation, "even when this necessitates one or more supplementary heat treatments."

Machinability is dependent partly on two factors, degree of hardness and uniformity of hardness. The annealing operation actually reduces the degree of hardness by from twenty to forty points on the Brinell scale. It also serves to free the surface of such foundry sand that is too tightly adhering to be removed by sand blasting and must be scaled off. By the relief of strained and chilled parts of castings, the whole mass is brought to a common hardness so that a tool will pass uniformly across or through any section without jumping or chattering.

Having established in our own minds the absolute necessity for annealing, what are the most essential things to point out to consumers to convince them of the desirability of buying only thoroughly annealed castings?

Obviously, the first point is strength. The fact that steel castings are specified indicates that there is need for higher physical properties than those found in malleable or gray iron. Having specified a material calculated to give a certain strength, it is clearly economy to pay two or three percent more to be certain that the calculated strength is present in effective form, not partly vitiated by unrelieved strains and not short-lived under shock due to unrefined coarse crystalline structure.

The second point is to explain to consumers that the castings made by plants in the Electric Steel Founders' Research Group are thoroughly annealed. The detail of annealing practice is very clearly given in our inspection standards which specify the temperature to be used, 1600 F. to 1650 degrees F.; the maximum time during which castings must be held at this temperature; the method of ascertaining the temperature by means of a recording pyrometer. They further require that fracture test pieces be placed on each annealer load. These test pieces are fractured after annealing and the appearance of the fracture affords index to the thoroughness of the annealing.

Finally, the consumer must be impressed with the idea that the care exercised in securing perfect annealing is representative of the care displayed at every point in the manufacturing of castings at plants in the Research Group.

Some Aspects of Railway Electrification

By HOWARD S. NILAN

Most of us are familiar with the reasons advanced why railroads should electrify; the saving of fuel; less maintenance cost of locomotives; doing away with roundhouses, fuel stations, water stations, etc. Yet we see railroads, not only not availing themselves of the electric locomotive to any considerable extent, but apparently becoming more and more committed to the steam locomotive and its inherent limitations. In other words, the trend of things does not seem to be toward the electric locomotive, in spite of the considerable number of electrical installations in the country and their successful performance.

When the B. & O. R. R. electrified their Baltimore tunnels in 1895, they broke into the field of the steam locomotive, and solved a very distressing problem for themselves, and it was accepted by very many people as the forerunner of the day, not far distant, when the steam locomotive should be no more. This was over 28 years ago, and I believe that very few people expected to have to wait that length of time to see the iron horse extinct. Yet the fact is that the real horse of flesh and blood is very much more nearly extinct.

Some ten years or more later came the New York Central and The New Haven with their New York City electrification. This was due to legislation following a disaster due to locomotive smoke. Later these were extended beyond the original limits for reasons which will appear later in this paper.

Other electrifications followed about as follows:

Pennsylvania R. R. (New York and Philadelphia).
Great Northern (Cascade Tunnel).
Norfolk & Western.
Boston & Maine (Hoosac Tunnel).
Grand Trunk (Port Huron Tunnel).
Chicago, Milwaukee & St. Paul.

In all the above, except the last, the impelling cause was tunnels and smoke, or in case of the Norfolk & Western a very short congested district having traffic beyond the capacity of the trackage and no way out except to increase the speed of the trains very materially, which was not possible with the steam locomotive.

Now practically all of the above railroads were electrified for special reasons, not common to the ordinary railroad. True, electrifications once started have been extended beyond limits, but mainly in the effort to get some benefit from the large initial investment. A five- or ten-mile electrification is a nuisance in that no operating expense is saved and a large addition is made to it. For an electrification to stand on its own feet, so to speak, it must extend over at least one operating division.

The Pennsylvania electrification in Philadelphia was necessary since the limit of the Broad Street station had been reached, and it was necessary to cut out all idle movements of trains and equipment, which the motor-equipped passenger car is able to accomplish to almost 100 per cent. If this had been a through station, instead of at the end of a line, the chances are that Philadelphia electrification would never have been made.

The Milwaukee electrification is in mountainous sections; it had not reached its limit of traffic capacity; it has no severe tunnel conditions. It is in competition with other railroads in the same territory handling heavier traffic by steam and successfully so, so that its case for the electrification of 650 miles is not fully established. Yet I know that as a means of handling the existing freight and passenger business, it is a perfect success. Undoubtedly at some future time it will prove equally successful as a financial undertaking.

In summing up then, as far as we have gone, it would appear that in the present state of the art the electric locomotive, or electrification in general, has proved that its field of usefulness is fully established in those special cases where the inherent limitations of the steam locomotive can not be tolerated, such as smoke and its limit of capacity. And since smoke is not accounted such a great nuisance in the open country, nor is its limit of capacity such a serious matter on a moderate profile, it is still maintaining its lead and undoubtedly will for many years to come.

It is true that the electric locomotive can enter any field that is occupied by the steam locomotive, and that the converse is not true, yet the fact is that it is not being generally adopted, and I think a little analysis will show why.

Taking the operating sheet of a large railroad for a recent year, we find that the percentages of the various operating accounts (expenses) are as follows:

Station Service	7.2
Yard Service	7.1
Engine Service	20.
Train Service	7.2
Casualties	4.2
Miscellaneous Transportation	3.2
Maintenance of Equipment	22.2
Maintenance of Way and Structures	23.5
Traffic	1.1
General	2.6
	98.3%

By electrifying the road only a few of the above items would be affected to any considerable extent, viz., engine expenses, maintenance of equipment, and maintenance of way and structures. The other items would be affected incidentally but not to any great extent.

The two largest items to be affected favorably are engine expense, 20 per cent, and maintenance of equipment, 22.2 per cent. If we assume that engine expense would be reduced 50 per cent and maintenance of equipment 20 per cent (m. of e. includes cars and other equipment as well as locomotives), we would therefore reduce the total operating expense by 14.6 per cent. And to do this we must electrify the entire railroad.

Practically, of course, this is absurd, and we know that we could avail ourselves of the greater part of these savings without electrifying the whole railroad, but the greater part of the main lines would have to be electrified. To do this would require an enormous increase in the capitalization, and a very large incidental increase in the item of Maintenance of Way and Structures. (The trolley or other contact system is not classified as Way and Structures, but as Power Distribution Systems, and the supporting structures as Power Line Poles and Fixtures by the I. C. C. accounts. By any name whatever it is a structure that must be maintained.) This would go a long way toward neutralizing the 14.6 per cent saving shown above.

My conclusions are then, that electrification of railways under present conditions is justifiable in spots, and that it will be done slowly in the future as in the past. It is not at all justifiable to any wholesale extent as we, as electrical men would perhaps like to see. For it to be otherwise there must be a vast change in conditions as we know them now, and I can foresee only the electrification of main lines of roads having very dense traffic in any event.

It is unsafe to set oneself up as a prophet, so I am not going to predict what is to be in the railroad world. Prognostications in the business world are only reliable when based on all the facts, and at present we do not know all the facts. Among many other things to be considered we must include the psychology of the mob. No one knows as yet what far reaching changes will take place in the business and social world due to this and kindred causes.

Assuming, however, that we are going to stay safe and sane, or perhaps may become more so, we may conclude that the problem of electrification is going to be influenced by the growth of our great power systems. It is a fact that the cost of power is going to become more and more important, since civilization is requiring greater amounts of power per capita of population as time advances. It will therefore become more necessary to reduce power waste and waste in its production. It will also become more important to utilize all possible sources of power, some of which are now going to waste.

Cheap fuel is gone, due to the tremendously increasing demands for fuel, and this problem is growing more important and serious from year to year. The increase in the efficiency of power limits is trying to keep step with the increasing cost of fuel, but it can not keep up indefinitely.

As a means of keeping down the cost of fuel used for power, or what amounts to the same thing, of getting more out of our fuel resources, the most promising is the super power stations. Provided our lawmakers do not regulate the power companies out of existence, or legislate against their growth, these power systems will develop into a supreme power system, which will collect power from all possible sources.

On our largest railroads, carrying dense traffic, electrified districts will take their power from the power system, while less busy lines and districts will continue to use the steam locomotive.

Another thought is interesting to follow. Twenty-five years or more ago, in advocating the use of electric power shops, etc., the argument most used was that you could save power by eliminating belts, shafting, etc., and on Sundays, nights, etc., you would not have to run the whole shop when necessary to run a lathe or any other single tool. Very good arguments, indeed, but this alone would not have electrified very many shops. The reason that practically all shops are driven electrically today is that electrical drive revolutionized the shop methods and management due to individual drive. It is no longer necessary to keep the heavy machines nearest to the source of motive power, but they can be located wherever they can be most efficiently operated. Increased efficiency and output is possible due to the possibility of scientific laying out of the shop and the logical routing of the material in process of manufacture. Tools have been speeded up and far greater utilization obtained of plant and labor employed. Tools have been modernized, due to the flexibility of the drive. In fact the entire mechanical world has been revolutionized through electric power. The benefits of electric power are not that it saves power or that electricity is cheaper than steam, or that a greater percentage of the power originated is actually delivered to the tool, as is the corresponding argument for electric traction, but that it was able to revolutionize shop methods through scientific design of plant, tools and management.

Wholesale electrification of railways must come, if at all, as a consequence of the possibility of so increasing the output and efficiency of the plant, tools, management and men as to more than offset the increased capitalization necessary for its installation. The mere substitution of one kind of motive power for another, even if it costs less to operate, is not sufficient.

Another aspect of the subject: Electrification does not, or does not need to mean merely the electrification of the tractive power, but all the facilities possible must be mechanized through electricity. To keep step with the growth of business and to keep its share of the transportation of the country, our railroad system has before it the necessity of creating additional facilities to give the service now being demanded.

The greatest chance for improved efficiency in railroading to my mind, is in increased speed of movement, directly and indirectly. Directly, by the greater speed of the trains; indirectly by quicker release of the goods transported, to the consignee. This latter is a terminal problem, and requires improvement of plant and method, and in its solution increased use of electric power would be a very great factor.

Test of a Decapod 2-10-0 Locomotive of the Pennsylvania Railroad

Showing the Efficiency of the Half-Stroke Cut-Off Locomotive

The Pennsylvania has issued its Bulletin No. 32, giving the results of tests made on the Altoona locomotive testing plant of a Decapod (2-10-0) locomotive No. 4358 of which 475 are in service on the road.

The following are the principal dimensions of the engine tested:

Weight in working order, lbs.	386,100
Weight on drivers, lbs.	352,500
Weight of engine and tender in working order. .	590,900
Tractive force (calculated) lbs.	90,024
Tractive force per lb. m. e. p.	480
Driving wheels, diameter, inches	62
Wheel base, driving, feet and inches	22–8
Wheel base, total, feet and inches	32–2
Wheel base, engine and tender, feet and inches.	73–½
Cylinders (simple) diameter and stroke, inches.	30½ x 32
Valves (piston) diameter, inches	12
Valve motion, type	Walschaerts
Boiler pressure, lbs. per sq. inch	250
Firebox, type	Belpaire
Grate area, square feet	70
Small flues, number	114
Small flues (outside diameter) inches	2.25
Large flues (for superheater) number	200
Large flues (outside diameter) inches	3.25
Flues, length, inches	228
Heating surface, flues, square ft. (fireside). . . .	4,104
Heating surface, firebox (fireside) (including arch pipes), square feet	287
Evaporative heating surface (fireside) sq. ft. . .	4,391
Superheating surface (fireside) square feet. . .	2,410
Heating surface, total (fireside), square feet. .	6,801
Feedwater heater (open type)	Worthington
Stoker	Duplex
Ratio of weight on drivers to tractive force. .	3.9
Total heating surface to grate area	97.1
Flue surface to firebox surface	14.3
Superheating surface to evaporative heating surface	0.55
Length of tubes, feet	19

The weights are so adjusted that nearly 91 per cent of the whole is carried on the drivers.

The boiler is of the extended wagon top type with a Belpaire firebox, and it is fitted with the Locomotive Superheater Company's type E superheater. The ashpan has an air inlet area of 13 sq. ft. which is equal to 19 per cent of the grate area and the air inlets of the grate have an area equal to 32 per cent of the surface.

The front end arrangement differs from the usual Pennsylvania design in that because of the use of side headers for the superheaters it has a cross-over steam pipe and the gas passage at the exhaust nozzle is enlarged by a depression in the cylinder saddle.

The cut-off in full gear is designed to be at 50 per cent of the stroke in accordance with the general design of the Decapod, (2-10-0) locomotive, the tests of which were described in the February, 1920, issue of RAILWAY AND LOCOMOTIVE ENGINEERING. Starting is insured in the usual way by the use of auxiliary ports measuring ⅛ in. by 1½ in. which remain open after the main port cut-off takes place and remains open up to 80 per cent cut-off.

The tractive force at starting, for a locomotive with 90 per cent cut-off, is assumed to be based on a mean effective pressure equal to 85 per cent of boiler pressure. Similarly, for a locomotive with 50 per cent maximum cut-off, and an auxiliary port cutting off at about 80 per cent of the stroke, the tractive force at starting is assumed to be based on a m. e. p. which is 75 per cent of boiler pressure. On this basis, the calculated tractive force of the I 1s locomotive is 90024 pounds.

This is the first class of locomotive on the Pennsylvania Railroad on which a feedwater heater is standard equipment. The heater is of the Worthington open type, in which the feed water is heated by a mixture with exhaust steam.

The calorific value of coal used in the tests was 13,658 British thermal units.

That the opening in the sides of the ashpan were ample to provide all of the air needed is evidenced by the fact that even when the fire was forced to the burning of 200 lbs. of coal per sq. ft. of grate area per hour, the vacuum in the ashpan was less than ½ in. of water; while in front of the diaphragm in the smokebox it was about 16¼ in. When burning about 100 lbs. per square foot of grate per hour the vacuum at the latter point was about 8¾ in. This maximum coal consumption of 200 lbs. per sq. ft. of grate area was equivalent to about 16,000 lbs. per hour for the firebox.

The type E superheater, with which this engine is fitted, has 100 units with a steam passage area of 70 sq. in. The drop in pressure between the boiler and the steam chest, due to friction in the superheater tubes, amounted, when the engine was using 20,000 lbs. of steam per hour, to about 1½ lbs. per sq. in.; while, when the steam consumption had risen to 60,000 or 65,000 lbs. per hour the drop was 12 lbs.

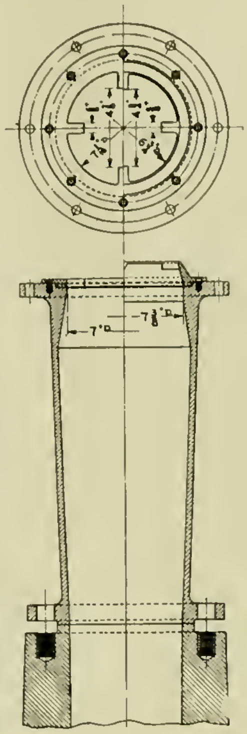
With the normal steam pressure of 250 lbs. per sq. in., the superheater ranged from 100 to 277 degrees Fahr. The steam temperature increased rapidly with the increase in coal fired, up to a rate of about 160 pounds per square foot of grate per hour after which a greater rate of firing produced little or no increase in temperature. Under general working conditions the steam temperature ranged from 20 to 30 degrees higher than the smokebox gases; but it so happened that in one case they both reached a maximum of 670 degrees Fahr., when the rate of combustion was 159 lbs. of coal per square foot of grate per hour.

When the first tests were made the locomotive had an exhaust nozzle 7⅜ inches in diameter with four projections. The net area of the nozzle was 40 square inches, and with the maximum evaporation was 53,473 lbs. of moist steam per hour. In this 11,235 lbs. of coal per hour were burned; the steam temperature was 631 degrees and the boiler showed an efficiency of 44 per cent. This result was thought to be low and the diameter of the exhaust nozzle was changed to 7 inches with four projections, making the net area of the nozzle 35.9 square inches, equivalent to a 6¾ in. diameter circle.

With a coal consumption of 11,292 lbs. per hour the maximum evaporation was 62,538 lbs. or an increased evaporation of more than 20 per cent on practically the same coal consumption. While with a coal consumption of 15,304 lbs. per hour, the evaporation rose to 64,656 lbs. of moist steam; the efficiency of the boiler in the two cases being 51 and 39 per cent respectively.

A special type of nozzle tip shown in the illustration, in which the outside surface was tapered to facilitate the entraining of the smokebox gases, was then tried. The bore of this nozzle was 6¾ inches, and with four projections, the net area was 33.26 square inches, equivalent to that of a 6½ inch diameter circle.

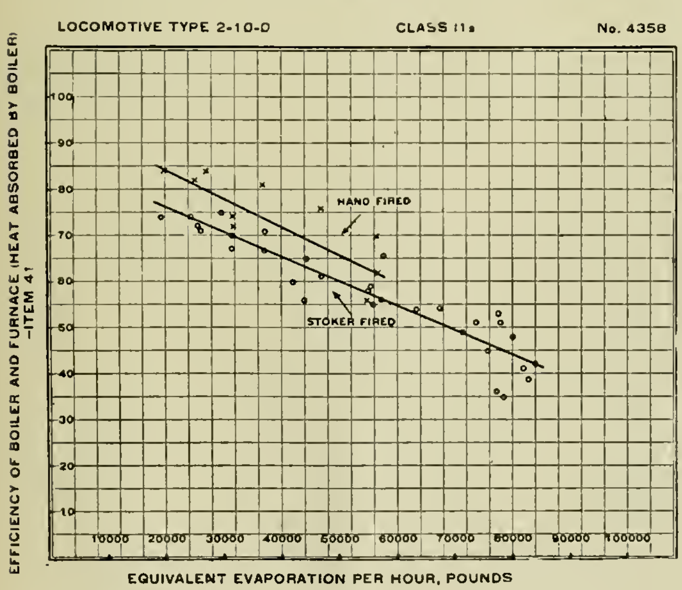
With this nozzle ¼ inch smaller in diameter than the standard nozzle, no increased evaporation was obtained nor was full boiler pressure maintained.



Exhaust Nozzle

The evaporative economy of the boiler ranged from 5.2 lbs. of steam per pound of dry coal fired to 10.8 lbs. when 77,394 lbs. and 19,505 lbs., respectively, were burned per hour, the corresponding boiler efficiencies being 36 and 74 per cent. The latter is considered to be the better measure as it is based on the heating value of the coal.

The illustration of the efficiency of the boiler shows that, when the locomotive is stoker fired, the efficiency, which is as high as 75 per cent at low rates of evaporation, decreases as the rate of combustion increases until it is only 35 per cent, when firing 16,000 pounds of coal per hour. This very low efficiency occurs only when the rate of firing is beyond the reasonable capacity of the boiler. The other illustration of the equivalent evaporation and coal fired, shows that practically the maximum evaporation of the boiler can be secured by firing 11,070 pounds of dry coal per hour, and when more coal is fired it is largely wasted as it results in only a slight increase in evaporation. It is interesting to note that at this rate of combustion, 159 pounds of dry coal per square foot of grate per hour, the maximum steam pressure was obtained.



Comparison of Hand and Stoker Firing As Affecting Boiler Efficiency

Attention is called to the higher efficiency that was obtained with this boiler, when stoker fired, than in boilers previously tested. The explanation of this is that, when the previous tests were made, it was when stokers were first introduced on the railroad and the firing was done by men whose only experience with stokers was obtained at the locomotive testing plant. Whereas in this test the locomotive was fired by men who had had long experience with stokers, in road service, and it is therefore probable that some of the increased boiler efficiency of this locomotive was due to better stoker firing. The assumption is confirmed by a comparison of the efficiency of the two boilers when hand fired.

The diagram showing a Comparison of Hand and Stoker Firing of this boiler as affecting its efficiency is exceedingly interesting as illustrating the oft-repeated claim of the superiority of the former. At the lowest rate of evaporation, the efficiency with the stoker is about 8 per cent less than for hand firing. When the equivalent evaporation reaches 55,000 pounds per hour, about the maximum rate at which a locomotive is worked in road service, the efficiency of the stoker firing is about 5 per cent less.

The test also included a careful measurement of the heat saved by the feed-water heater. The temperature of the water delivered by the heater depends upon the temperature of the exhaust steam, and this, in general, increases with the output of the locomotive.

The diagram of the Feed Water Temperature shows the temperature of the exhaust steam and the feed water at different rates of evaporation.

The temperature of the water delivered by the heater is from 7 to 37 degrees below that of the steam. The maximum temperature of the water delivered by the heater was 242 degrees F. where the temperature of the exhaust steam at the heater was 279 degrees, 37 degrees higher. The highest feed-water temperatures were reached when the locomotive was worked at a rate high enough to require the use of the injector to supplement the feed-water heater. During the high capacity tests the temperature and pressure of the exhaust steam were high, but since the amount of water delivered by the feed-water heater was limited by heater capacity part of the boiler feed water was supplied by the injector. The highest feed-water temperature in any test where the injector was not used was 218 degrees Fahr.

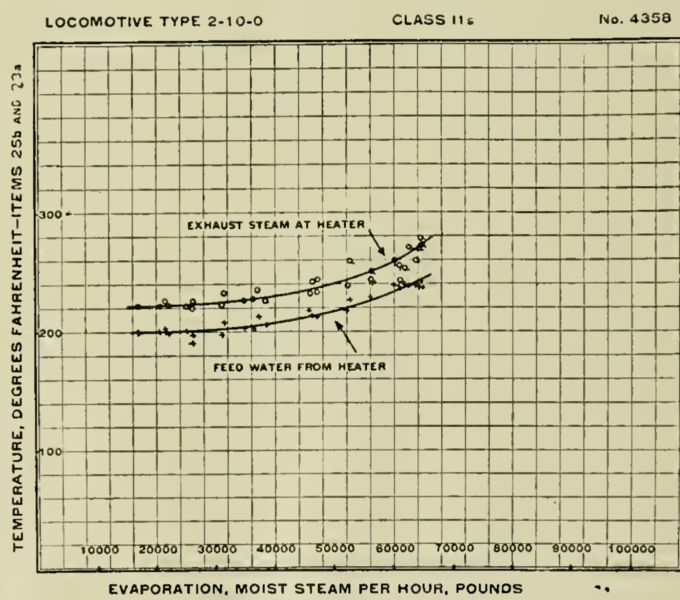


Diagram of Feed-Water Temperature

The direct saving varied from 7.4 to 10.2 per cent. in tests in which all the feed water was supplied by the heater. In road service a locomotive is seldom worked at a rate beyond the nominal capacity of the heater, but many of the tests on the plant were beyond this capacity.

In these tests there is an increase in the temperature of the water delivered by the heater, but the direct saving due to the heater falls as low as 4.7 per cent, because part of the boiler feed water is supplied by the injector.

The temperature rise is a very good measure of the direct saving.

Care should be exercised in the installation of a heater to avoid loss of water at the air vents. This loss of water at the air vent is undesirable in that it wastes water from the tender, but the tests do not show that a large water loss has any effect on the heat saving due to the feed-water heater.

The heater reduces the amount of water taken from the tender. The net saving of water by using the heater averages about 10 per cent, when the locomotive is worked at rates within the capacity of the heater.

At a given rate of combustion the temperature of the steam from the superheater is not affected by the use of a heater, but as less coal is burned to develop a given indicated horsepower the temperature of the steam is lower when the heater is used if a comparison is made at equal horsepowers.

In addition to the direct saving of the heater due to recovery of the exhaust steam from the locomotive, there is an indirect saving due to the fact that at a given horsepower the heater reduces the work of the boiler, and, therefore, increases the boiler efficiency. In order to determine the total saving due to the use of the feed-water heater, eight tests with the heater, covering a range of evaporation up to its full capacity, were repeated, using the injector only to feed the boiler.

The average coal saving in the eight tests was 13.9 per cent. In the eight tests made with the feed-water heater, the average temperature of the cold feed water was 9½ degrees lower than in the tests without the feed-water heater. This lower temperature increased the calculated saving of the feed-water heater but decreased the coal saving, when comparison is made with similar tests with the injector in use.

The heat recovered by the feed-water heater is a direct addition to the heat output of the boiler proper and the maximum steam capacity of the locomotive is therefore increased in the same proportion. During the tests at or near maximum boiler capacity, the heat recovered by the feed-water heater varies from 4.9 to 6.4 per cent of the heat output of the boiler proper, thereby increasing the maximum steaming capacity of the locomotive in the same proportion: an average of 6 per cent. The maximum heat ouptput of the boiler and feed-water heater of locomotive 4358 was 85,580,584 b.t.u. per hour.

As for the engine performance, the water rate which was 20.8 pounds per housepower hour at 40 r.p.m. and 20 per cent cut-off, falls to 15 pounds at 160 r.p.m. and 30 per cent cut-off. At all speeds above 60 and below 180 r.p.m. the water rate lies between 17½ and 15 pounds, except in the test at 120 r.p.m. and 55 per cent cut-off, where the steam pressure was not maintained because the maximum capacity of the boiler had been exceeded.

The influence of the feed-water heater is also felt in the engine performance; for, by reducing the amount of steam through the nozzle, it reduces the back pressure and, therefore, reduces the water rate.

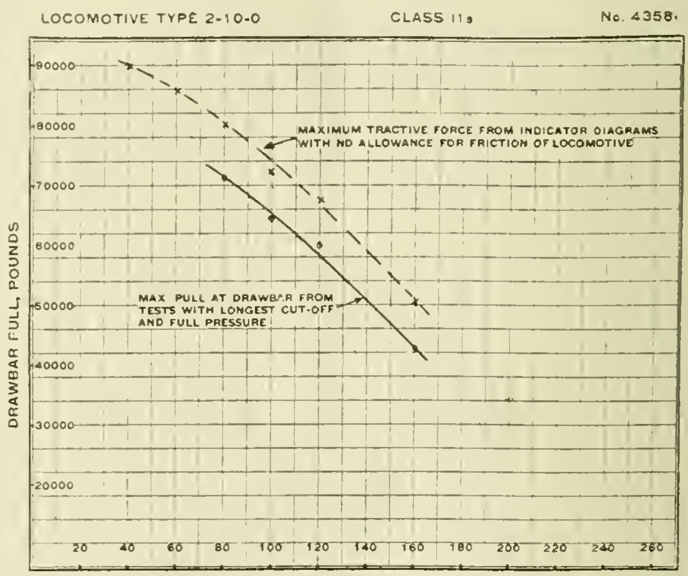
It is not unusual for an engineman to run a locomotive with a partially closed throttle and an increased cut-off. A short series of tests was made to determine the effect of this practice upon the water rate. The tests were all run at a speed of 80 r.p.m., the duration of the tests being one-half hour. On account of the short duration of the tests the coal was not measured. The method used was first to make a test with the throttle wide open, giving practically full boiler pressure at the cylinders, and with a cut-off of 20 per cent. The drawbar pull under this condition was 25,700 lbs. A test was then made at the same speed with the cut-off lengthened to 40 per cent and the throttle closed just enough to produce the same drawbar pull as in the first test. A third test was then run with the cut-off lenghened to 55 per cent and the throttle further closed to give the same drawbar pull.

Two series of these throttling tests were made. In the first test the feed-water heater was used. As the use of the feed-water heater requires a calculation to determine the amount of steam condensed from the locomotive exhaust, in order to eliminate all uncertainty that might arise from this cause, a second series of tests was run in which the feed-water heater was not used.

In the series of tests with the injector, the water was increased only 9 per cent from an average of 18.9 to 20.6 pounds in lengthening the cut-off from 20 to 55 per cent and reducing the steam chest pressure from 243 pounds to 96 pounds.

The performance of the locomotive as a whole is gauged by the coal burned and drawbar horsepower developed, but comparisons are also made on the basis of indicated horsepower. All the coal and water used in the tests is charged against drawbar horsepower, but the amount chargeable to auxiliaries is not included in that charged against indicated horsepower.

At 40 r.p.m. (7.1 m.p.h.) the coal burned per i. hp. is nearly a uniform amount of 2½ pounds at all cut-offs except 55 per cent, and the coal per drawbar horsepower about three pounds. At speeds of 40 and 80 r.p.m. (7.1 and 14.2 m.p.h.) the coal rate is shown to increase ab-



SPEED IN REVOLUTIONS PER MINUTE—ITEM 22

Maximum Drawbar Pulls

ruptly at cut-offs beyond 50 per cent. At speeds above 40 r.p.m. the coal rate per i. hp. hour is close to 2 pounds at all rates of working up to 2,500 i. hp. per drawbar horsepower, it is less than 3 pounds. Two tests show a coal rate as low as 1.9 pounds per i. hp. hour, and approximately 2½ pounds per drawbar horsepower hour.

It has not been possible to obtain as good economy with stoker firing as with hand firing and the charts are of interest in showing that, whatever economy has been lost by the introduction of the stoker, has been regained by the use of the feed water heater.

The maximum indicated horsepower of Locomotive 4358 was 3863 and was developed at a speed of 160 r.p.m. and 47 per cent cut-off and, by dividing the weight of the locomotive in working order, by this horsepower, we find that it weighs 100 pounds per horsepower.

The diagram of Maximum Drawbar Pulls gives some that were obtained at different speeds. Except at 160 r.p.m. the points are not the averages for the regular tests, but were obtained by special short runs in which the boiler pressure was held at exactly 250 pounds. At speeds below 60 r.p.m. the capacity of the dynamometer appeared to be exceeded and the figures for the three runs were omitted.

The amount of steam furnished by the boiler at speeds below about 15 m.p.h. is not the limiting factor in establishing the maximum drawbar pull, as then only a moderate weight of steam is required. The drawbar pull at these speeds depends upon the dimensions of cylinders and driving wheels for any given boiler pressure.

The machine efficiency of the locomotive had a wide range from 71 to 88 per cent. Over a long series of tests the variation in machine efficiency during duplicate tests is so wide that it is evident that the dynamometer readings are not always correct.

Before and after some of the tests there was a sudden change in the machine efficiency, indicating some change in the dynamometer. But regardless of this it is evident that the machine efficiency follows a regular law, which is, that it decreases with the speed and, at any given speed, increases as the power developed is increased.

One of the important conclusions reached as a result of the tests is that the addition of a feed-water heater resulted in a coal saving of about 14 per cent.

Shop Kinks

Some Handy Tools in Use in the Erie R.R. Shops

Cylinder Head Grinder

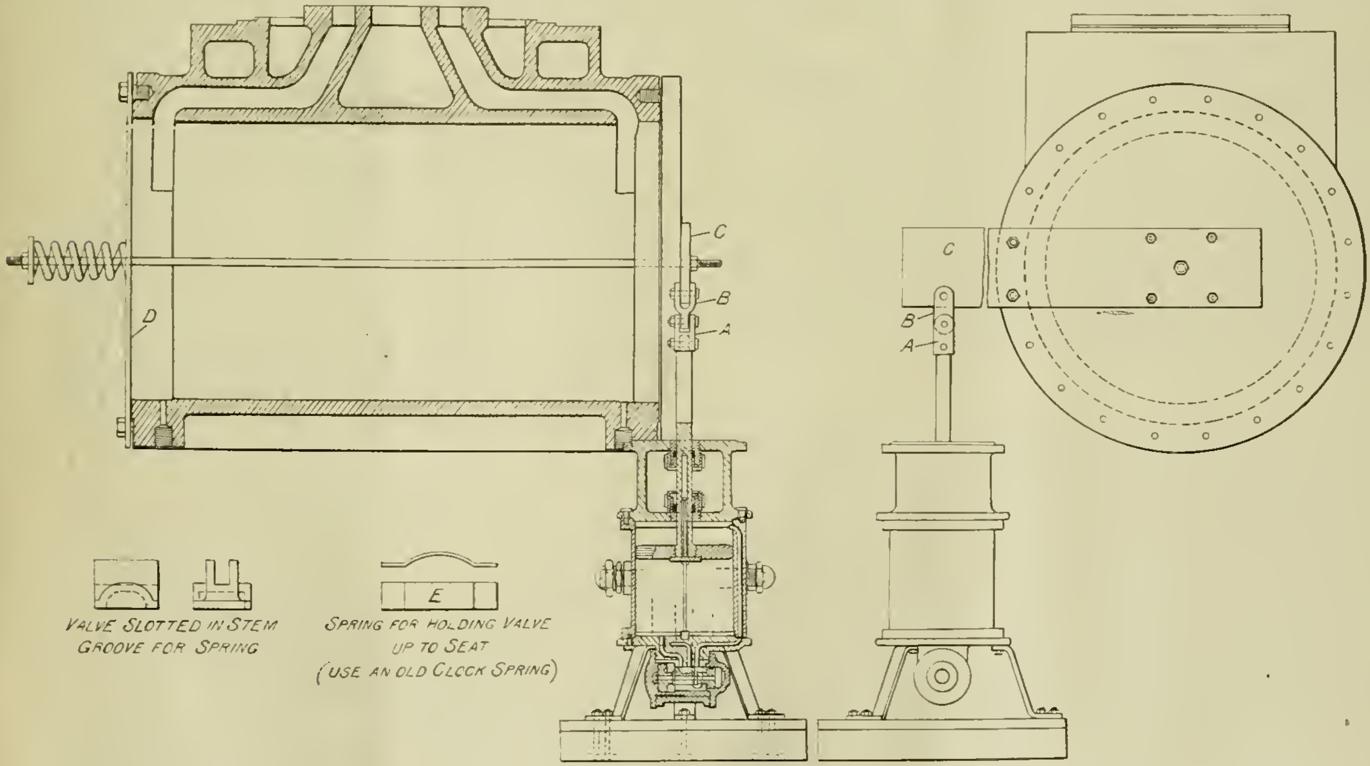
There seems to be no end to the useful purposes to which the discarded parts of the air brake apparatus may be applied. Discarded, that is to say, from the locomotives or cars as having outlived their usefulness in their original environment.

The cylinder head grinder, that is here shown, is the outcome of the utilization of the steam end of a 10 in. by 9½ in. by 10 in. Westinghouse air pump.

to the push rod knuckle *B* by a 13/32 in. diameter pin, and the latter grasps the operating lever *C* to which it is connected by a 9/16 in. pin.

The lever is made of ⅞ in. by 8 in. material and is bolted to the outer edge of the flange of the head to be ground.

The head is set in place on the end of the cylinder and is held there by a spring made of ½ in. round steel. It is 2½ in. in diameter and 6 in. long. The spring is held by



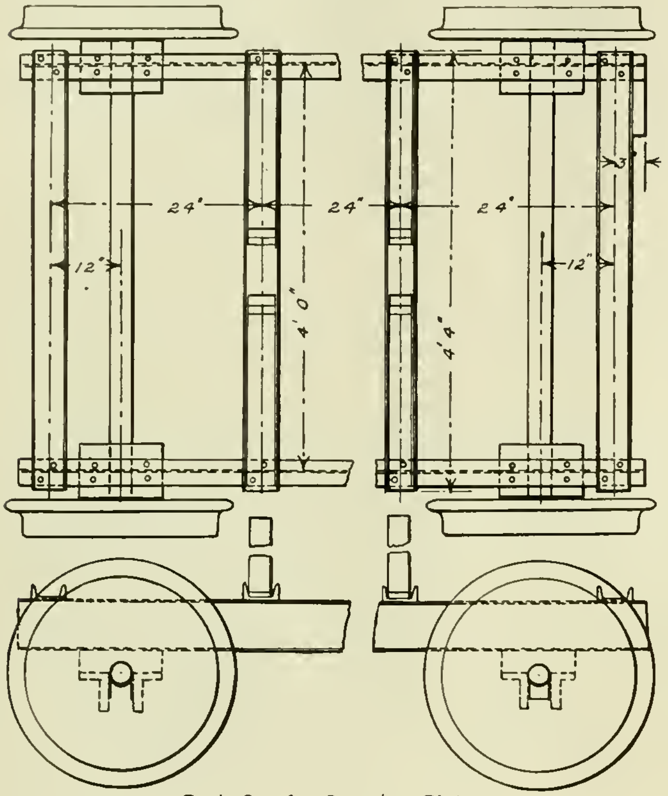
Cylinder Head Grinder

The steam end is set up on three legs made of ½ in. by 2 in. iron, bolted to a wooden base 24 in. square. These legs with the base, lift the lower cylinder head 10¼ in. from the floor. The air end of the pump is removed and the separator left in place. The threads at the upper end of the piston rod are cut off and the rod turned down, at the end, to a diameter of 31/32 in. for a distance of 1½ in. To this the pushrod jaw *A* is pinned. This is coupled

a brace *D* of 1 in. by 4 in. steel held in place by two 1 in. bolts passing through slotted holes at the ends and reaching to a brace at the other end of the cylinder. While the whole is steadied and brought up to exert the proper pressure on the cylinder head, by a 1¼ in. bolt that runs through the center of the cylinder.

With the machine set up in this way, an air connection is made to the pump cylinder, whose piston at once starts up an oscillating motion which is communicated to the cylinder head. The grinding can thus be done far more rapidly than by hand and with the expenditure of little or no manual labor.

The only change that need be made is to increase the size of the spring for holding the head in place when the work is done on large cylinders.



Push Car for Carrying Plates

As the position of the pump cylinder is reversed from the one which it occupies on a locomotive, it is necessary to provide a means for holding the operating valve against its seat, otherwise it would fall away from it as soon as the air supply was cut off. This may be accomplished by slotting the valve as shown in the drawing and holding it in place by a light spring *E* which may be made from an old clock spring.

Push Car For Carrying Plates

Push cars designed for a special purpose are something of a rarity. Here is one designed for carrying boiler plates from the storage platform to the shop.

The moving of such plates on an ordinary push car is always difficult, because, when laid flat, they either interfere with the wheels or are too large to pass through the clearances or both. This car meets the difficulty by carrying the plates on edge.

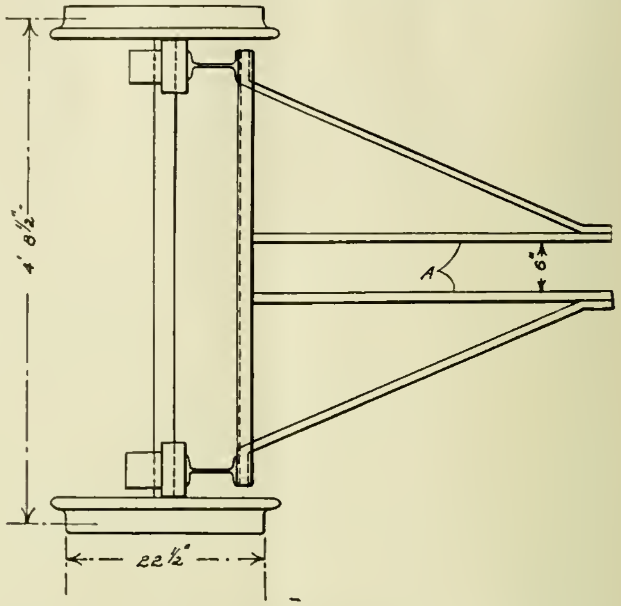
The wheels are 22½ in. in diameter at the tread and are mounted on axles with inside bearings 2½ in. in diameter. The side frames are of 6 in. I beams and the end pieces and cross bearers are of 4 in. channels laid with the flanges up. The cross bearers are set 24 in. from center to center and the same distance at each end from the end pieces. The I beams are 6 ft. 6 in. long.

Each of the two cross bearers carries a frame built up of 2¼ in. by ¾ in. flat steel. There are two uprights *A* set 8 in. apart at the center, with feet riveted to the bearers, as shown, and rising to a height of 3 ft. 6 in. These uprights are braced on the outside by braces running down and riveted to the outer ends of the channels.

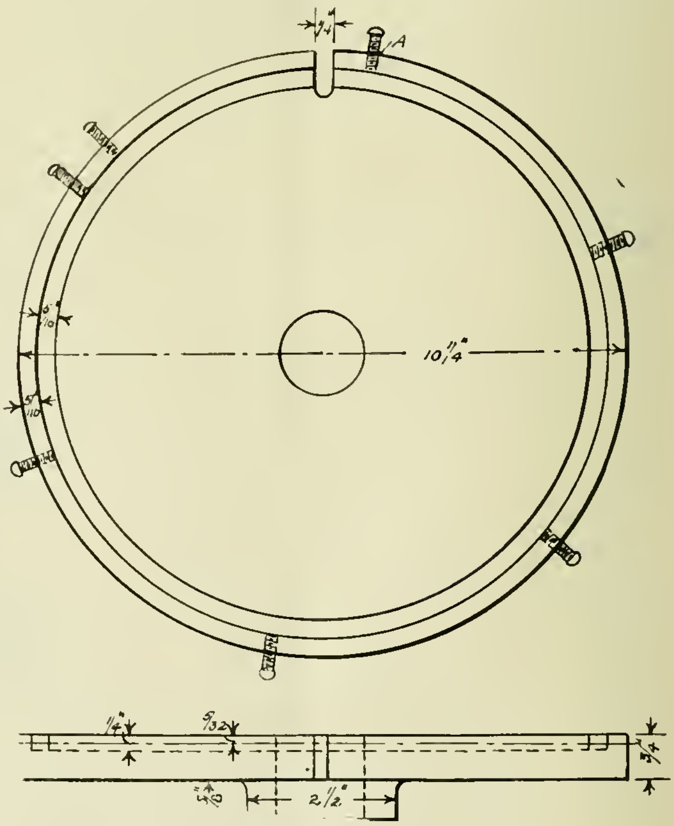
These frames thus form a pocket 8 in. wide. 26¼ in. long and 42 in. deep into which the plates can be set on edge, while the end pieces form a base 6 ft. 4 in. long upon which they can rest.

Chuck for Holding Air Pump Packing Rings

This chuck is intended for holding 9½ in. pump packing rings while they are being faced off in a lathe. It



consists of a plain cast iron disc ½ in. thick with a hub extending back for ⅝ in. which is bored and threaded to fit the spindle of the lathe upon which it is to be used.



Chuck for Holding Air Pump Packing Rings

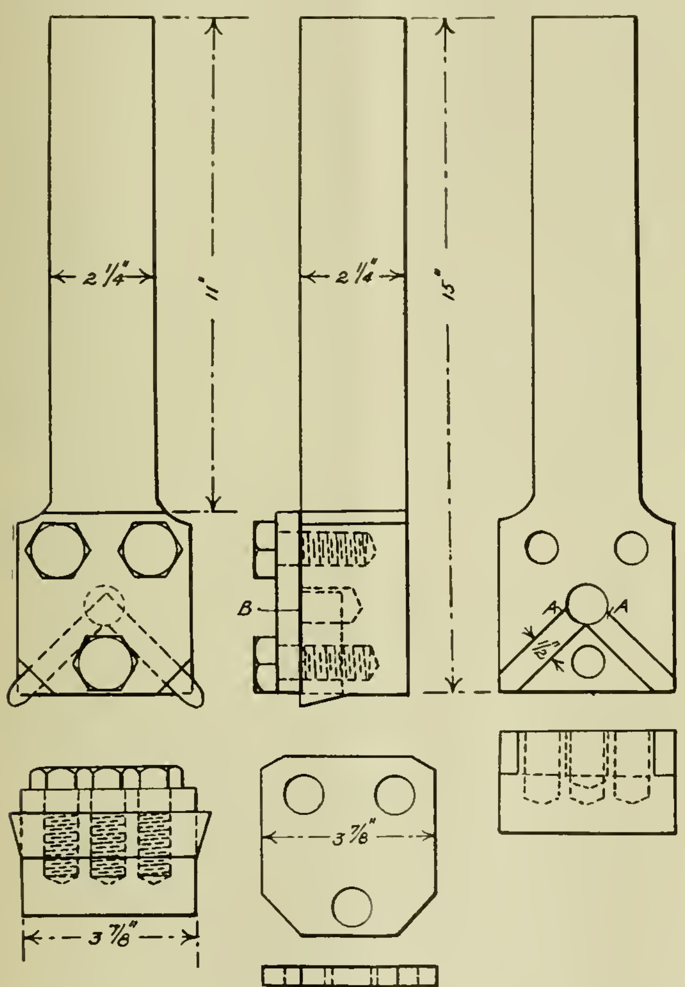
There is a ledge 5/16 in. thick around the outside which is drilled and tapped for seven 3/16 in. button head machine screws *A*. These are drilled along the dotted line of the side elevation 5/32 in. from the edge.

The method of using is apparent. The ring is laid against the face of the chuck inside the ledge and is held by the button head machine screws, and can be quickly set and removed.

Double Cutter for Shoes and Wedges

This cutter is intended for use on a planer where shoes and wedges are being finished in a gang chuck. It consists of a holder in which two grooves *A* are cut at an angle of 45 degrees with the center line of the stem of the holder and at right angles to each other. These grooves are ½ in. wide and 15/16 in. deep. The cutting tools are of the shape shown in the engraving and are held in place by the cover plate *B*, which is, in turn held by three ¾-in. tap bolts.

The tool is set up so that the outside cutting faces of



Double Cutter for Shoes and Wedges

the two tools are the proper distance apart to finish the inside faces of the two flanges of the shoes or wedges upon which the work is being done.

The tool having been thus prepared is put in the tool post of the machine and fed down into the wedge or shoes until the proper depth is reached. This finishes the two flanges at one cutting and one setting, and it can be done either before or after the bottom or flat surface has been planed.

New York Railroad Club Dinner

The annual dinner of the New York Railroad Club will be held at the Hotel Commodore on Thursday evening, December 18. Dr. David Friday, professor of economics at the New School for Social Research, New York, will speak on "What the Future Holds for the Railroads."

Snap Shots—By the Wanderer

There is an old definition to the effect that engineering is the science of converting the forces of Nature to the uses of mankind. I sometimes think that a more practical definition of the work of an engineer would be that it is that of a man who is engaged in getting himself and others out of trouble. For the successful engineer of any rank from workman to chief is the man who can meet and provide for a condition or an emergency that has never arisen before. And such emergencies are of everyday occurrence in every shop. If this were not so, there would be no need for foremen or superintendents, merely overseers to see to it that the man worked.

Occasionally, curious enough, some little thing will be sufficient to puzzle a gang and stop work, because there is no one who is enough of an engineer to think of a way out of the difficulty; and sometimes the difficulty is one so easily overcome that the lack of thinking capacity of men who fail to solve these simple problems becomes truly pathetic.

For instance, a steam shovel was working alongside the track of an electric road and finally reached a cross wire which was too low to permit the boom of the shovel to pass beneath, and there was nothing with which the wire could be lifted except a ladder, which was too short, when resting on the ground to do it. So the shovel stopped working and the gang waited until an engineer could come from headquarters to tell them what to do.

There was a pile of ties at hand. These were used to make a crib and the ladder put on top, thus lifting the wire clear of the boom. It was such a simple thing and yet in the whole gang there was not a man with imagination enough to do it.

Speaking of imagination, engineers are usually regarded in this country as a class quite devoid of that,—shall I call it,—artistic quality. The French look at it quite differently. The superintendent of motive power does not design the new type of locomotive for which he is responsible. He *imagines* it. That is, the general features of the machine, the creation of his brain, exist in his imagination before they can possibly take shape on paper or in metal. And it is in the possession of a vivid imagination coupled to an initiative to give material expression to the creatures of his imagination that is essential to success as an engineer.

Returning to the gang who could not think of putting the ladder on the cribwork to lift the trolley wire, there is an axiom that should be written large in the inner recesses of the brain of every workman, foreman, superintendent and manager, and it is: "You can always find something that will do. It may not do very well but there is always something available that will serve to help over a rough place. And nowhere is there a greater exemplification of the truth of the injunction: "seek and ye shall find," than in the everyday life of the practicing engineer and mechanic and nowhere is the faculty of finding that something more valuable than in the shop and in the field. Modern industrial methods do not tend to foster this search for something that will do, for labor is too expensive and time too precious to be wasted in hunting for something that will do. It is for that reason that a certain engineer friend of mine always congratulates himself that he learned his trade in a country jobbing shop where they had few tools and no conveniences and where every job was the subject of study to see how it could be done and it is to this training that he attributes much of his later success. The crude devices resorted to in order to accomplish the simple operations of a well-equipped modern shop are enough to fill a volume. Some day I will try and gather details of the devices that my friend is fond of talking about and present them for the amusement of my readers.

However, if any of them are impatient for immediate results let them turn a page or two to Shop Kinks. In this monthly display of handy tools we have a proof of what I have been saying. The men responsible for this display of ingenuity, which you will notice comes from the same root word as engineer, have almost literally been obliged to fabricate bricks without straw. They have resorted to the scrap heap for a large portion of their building material. They have taken old air brake cylinders, discarded structural shapes, rods, bars and plates that had outlived their usefulness and have fashioned them into a multitude of devices to save labor, increase efficiency and cut down expense, without waiting for the slow process of a requisition to go and come back denied.

I sometimes wonder how much of real appreciation these men of imagination receive not in words, for those rarely if ever come, but in thoughts from the managing officials. Does it ever occur to them that no small portion of their declared dividends have been made possible by the begrimed foremen scattered over their lines who, by the exercise of imagination and mechanical skill have made not two, but twenty, thirty, forty, brake hangers, gibs, keys, bushings, rings, packings wih a long accompaniment of et ceteras to grow where but one grew before? How many executives have even a suspicion that such things exist?

Yet, in the final analysis, it all sifts back to our original proposition and rests on a basis of imagination, initiative and mechanical skill.

That these traits can be cultivated there is no doubt, but it is also true that they must be to a large extent natural endowments, the inheritance of acquired characteristics. There can be no doubt that the hard surroundings and meagre resources of primitive New England, with the pressing need of such a mother as Invention, are responsible for all that we know under the generic term of Yankee ingenuity. As a race we have grown to think in terms of new devices; and it is a thing that has won a worldwide recognition.

A friend told me of attending a meeting of Austrian engineers where one of their number was attempting to demonstrate his ideas by a blackboard sketch in which he had great difficulty in drawing some irregular parallel lines. After nervously watching him for a time, my friend stepped up, showed him how to use two crayons at once, and the thing was done. Then came the admiring exclamation from all over the room: "Ach, these Americans are so practical."

Practical! Yes. But not only practical but imaginative. So it seems to me that it is not only the imaginative artist or poet who puts soul into a picture or a sonnet, but also that cool headed, calculating engineer or foreman who draws upon the vividness of his imagination and puts a soul into his locomotive or shop kinks.

Motive Power Condition

Class I railroads on November 15th had 11,637 locomotives in need of repair, or 18 per cent of the number on line, according to reports filed by the carriers with the American Railway Association.

This was an increase of 542 locomotives over the number in need of repair on November 1st, at which time there were 11,095 or 17.2 per cent.

Of the total number 6,485 or 10 per cent were in need of classified repair, an increase compared with November 1st of 294 while 5,152 or 8 per cent were in need of running repair, an increase of 248 during the same period.

Class I railroads on November 15th had 4,818 serviceable locomotives in storage, an increase of 42 over the number in storage on November 1st.

The railroads during the first half of November repaired and turned out of the shops 35,420 locomotives, a decrease of 813 compared with the number repaired during the last half of October.

Illinois Central Buys $25,000,000 of Equipment

With the explanation that "no phase of the railway business is more important to the public than that of adequate service," the Illinois Central has published a statement showing the aggregate amount of its orders placed during the month of November at a total cost of more than $25,000,000. The new equipment is as follows:

2,000 40-Ton Composite Box Cars	$ 4,460,000
4,000 50-Ton Composite Gondola Cars	8,112,000
200 Steel Underframe Stock Cars	401,000
200 Express Refrigerator Cars	917,600
25 Mountain Type Locomotives	1,691,375
3 Steel Parlor Cars	114,000
30 Steel Coaches	786,750
8 Steel Compartment Coaches	220,800
6 Steel Chair Cars	170,604
9 Steel Baggage Cars	170,001
10 Steel Baggage-Mail Cars	221,740
215 Steel Suburban Cars Equipped for Operation by Electricity	8,250,000
Total	$25,515,870

Notes on Domestic Railroads

Locomotives

The Terminal Railroad Association of St. Louis, Mo., has placed an order for 15 eight-wheel switching locomotives with the Baldwin Locomotive Works.

The Peoria-Pekin Union Railway has ordered 3 0-8-0 switching locomotives from the Baldwin Locomotive Works.

The Delaware, Lackawanna & Western Railroad has placed an order with the American Locomotive Company for 2 three-cylinder Mountain type locomotives.

The Missouri, Kansas, Texas Railroad has ordered 10 eight-wheel switching locomotives from the Lima Locomotive Works.

The Lehigh & New England Railroad is inquiring for 8 consolidation type locomotives.

The Michigan Central Railroad has placed an order for the building of an experimental Pacific type locomotive with the American Locomotive Company.

The Central Railroad of New Jersey has placed an order for 10 Mikado type locomotives with the Baldwin Locomotive Works.

The Louisiana & Arkansas Railway has placed an order with the Baldwin Locomotive Works for 2 Mikado type locomotives.

The Chicago & Northwestern Railway is inquiring for 50 sets of locomotive boilers and fire-boxes.

The Norfolk & Western Railway is inquiring for 10 locomotives.

The Kahului Railroad Company of Hawaii has ordered one Mikado type locomotive from the Baldwin Locomotive Works.

The Caddo River Lumber Company has ordered one Prairie type locomotive from the Baldwin Locomotive Works.

The New York Central Railroad is inquiring for 50 tenders.

The Wabash Railway has placed an order with the American Locomotive Company, for 50 Mikado type locomotives, 5 of which are to be three-cylinder type locomotives.

The Southern Pacific Company is inquiring for 18 2-10-2 type locomotives with tenders having a capacity of 12,000 gal.

The Hydraulic Press Brick Company has ordered one 0-4-0 type switching locomotive from the Baldwin Locomotive Works.

The Pennsylvania Railroad has placed orders with its Altoona shops for the construction of 50 eight-wheel switching locomotives, to be known as class C-1.

Freight Cars

The Chicago & North Western Railway has placed orders for 3,200 freight cars distributed as follows: 500 box cars and 500 automobile cars with the Pressed Steel Car Company, 500 automobile cars and 200 refrigerator cars with the American Car & Foundry Company, 500 stock cars with the Illinois Car & Mfg. Company, 500 flat cars Standard Steel Car Company and 500 box cars with the Bettendorf Car Co.

The Wabash Railway is inquiring for 200 automobile cars also for 400 gondola bodies.

The Norfolk & Western Railway has placed orders for 3,000 all steel gondola coal cars 57½ tons capacity, divided 1,000 each to the following companies: Pressed Steel Car Co., Ralston Steel Car Co. and the Newport News Shipbuilding & Drydock Co.

The New York Central Lines have purchased 3,000 all-steel box cars of 55 tons capacity. The following companies will supply these cars: The American Car & Foundry Company, 1,000; Standard Steel Car Company, 1,000; Pressed Steel Car Company, 500, and the Merchants Dispatch, 500.

The Western Fruit Company has placed an order for 1,757 steel underframes with the Ryan Car Company.

The Great Northern Railway has placed an order for 1,500 steel underframes with the Streator Car Company, 1,000 steel car ends with the Union Metal Products Company and 1,000 steel roofs with the Standard Railway Equipment Company.

The Elgin, Joilet & Eastern Railway is inquiring for 500 steel underframes for freight cars.

The McKinney Steel Company has ordered from the Pressed Steel Car Company 10 flat cars of 100 tons capacity.

The Central of Georgia Railway has placed an order for 500 ventilated box cars with the Tennessee Coal & Iron Company.

The Great Northern Railway has placed an order with the Siemms-Stembel Company for 38 refrigerator car underframes and also is inquiring for 1,500 underframes for box cars.

The Southern Railway has placed an order for 1,000 steel underframes for freight cars with the Virginia Bridge & Iron Company.

The United States Rubber Company has placed an order for 3 tank cars with the American Car & Foundry Company.

The Graver Corporation has ordered 2 60-ft. flat cars from the Illinois Car & Manufacturing Company.

The Texas Company has ordered 1,000 tank cars of 10,000 gal. capacity from the Pennsylvania Car Company.

The Great Northern Railway has placed an order for 40 air dump cars with the Pressed Steel Car Co.

The Atchison, Topeka & Santa Fe Railway has ordered 500 gondola cars and 500 refrigerator cars from the American Car & Foundry Company, and 1,000 box cars from the Pullman Car & Manufacturing Corporation.

The Missouri Pacific Railroad has placed an order for repairs to 300 50-ton composite gondola cars with the American Car & Foundry Company.

The Baldwin Locomotive Works has placed an order with the Gregg Car Company for 100 flat cars for export.

The Long Island Railroad has purchased 15 caboose cars from the Pressed Steel Car Company.

The Central of Georgia Railway is inquiring for 500 ventilated box cars.

The Florida East Coast is inquiring for 10 tank cars of 10,000-gal. capacity.

The Great Northern Railway has placed an order for 25 underframes for caboose cars with the American Car & Foundry Company.

The Western Fruit Express Company is inquiring for 1,200 underframes for refrigerator cars.

The New Jersey, Indiana & Illinois Railroad has placed an order for 200 automobile cars with the American Car & Foundry Company.

The St. Louis-San Francisco Railway has placed an order with the Tennessee Coal, Iron & Railroad Company for 400 underframes for gondola cars.

Armour & Company, Chicago, Ill., has ordered 150 steel underframes from the Illinois Car & Manufacturing Company.

The New York, Chicago & St. Louis Railway is inquiring for 200 underframes for freight cars.

The Texas Company has placed an order for 1,000 tank cars with the Pennsylvania Car Company.

Passenger Cars

The Central Railroad of New Jersey is inquiring for 23 coaches, 5 combination cars and 2 club cars.

The Illinois Central Railroad has ordered 130 suburban motor cars from the Pullman Car & Manufacturing Company, and 85 suburban trailers from the Standard Steel Car Company. The electric control equipment was awarded to the Westinghouse Electric & Manufacturing Company and the General Electric Company.

The Chicago & North Western Railway has placed an order with the Oneida Manufacturing Company for Oneida power units for one combination car.

The Cleveland, Cincinnati, Chicago & St. Louis Railway has placed an order for 4 combination mail and express motor cars with trailers and one combination baggage and passenger motor car with the Sykes Company, St. Louis, Mo.

The Gulf, Texas & Western Railroad has ordered one gasoline motor and baggage car from the J. G. Brill Company.

The Great Northern Railway is expected to enter the market soon for 3 dining cars.

The New York Central Railroad has ordered one combination passenger and baggage car, one passenger trailer car and one combination baggage and mail motor car from the J. G. Brill Company.

The Asherton & Gulf Railway has ordered through Sugarland Industries one combination passenger and baggage gasoline motor car from the J. G. Brill Company.

The Central of Georgia Railway is inquiring for 5 coaches and one combination baggage and mail car.

The Great Northern Railway has placed an order for 12 passenger car underframes with the Minneapolis Steel & Machinery Company.

The Missouri Southern Railroad has ordered one combination passenger and baggage gasoline rail motor car from the J. G. Brill Company.

The Pennsylvania Railroad has ordered two combination passenger and baggage gasoline motor cars and one trailer car from the J. G. Brill Company.

Buildings and Structures

The Southern Railway plans rebuilding and expansion of its shops and enginehouse at Chattanooga, Tenn., to cost approximately $1,000,000.

The Pennsylvania Railroad has announced that its West Philadelphia shops are to be moved to a new location, outside the city, in furtherance of the city beautiful plans.

The Atlantic Coast Line Railway has awarded a contract to the Robert & Schaefer Company, Chicago, Ill.,, covering the construction of a 500-ton capacity circular reinforced concrete automatic electric four-track coaling plant for erection at Bennett's yard, Charleston, S. C.

The Wabash Railway has purchased 109 acres of ground in North Kansas City, and plans to construct thereon a new freight yard, including a roundhouse, machine shop, coal storage yard and office building.

The Illinois Central Railroad is reported to be planning shop extensions and improvements at Waterloo, Iowa, to cost approximately $1,500,000.

The Central of Georgia Railway has placed an order with the Robert & Schaefer Company, Chicago, Ill., covering an electric cinder plant for its shops at Columbus, Ga.

The Southern Pacific Company plans the construction of steel car repair shop buildings at Nampa, Idaho, to cost approximately $150,000.

The New York Central Railroad has awarded a contract for the installation of a complete blowoff washing and filling system for locomotive boilers at East Buffalo, New York, to the National Boiler Washing Company, to cost approximately $40,000.

The Cleveland, Cincinnati, Chicago & St. Louis Railway has placed an order with the Robert & Schaefer Company, Chicago, Ill., covering an electric cinder plant for its shops at Lafayette, Ind.

The Missouri Pacific Railroad plans the construction of a fuel oil station at Ewing avenue, St. Louis, Mo.

The Chicago, Rock Island & Pacific Railway has awarded a contract for the construction of a brick and frame addition to the roundhouse at Rock Island, Ill., to cost approximately $25,000.

The Gulf Coast Line has awarded a contract for the construction of a machine shop, power house and store house at De Quincy, La., at a cost of approximately $50,000.

The Delaware, Lackawanna & Western Railroad has awarded a contract for the furnishing and erection of a 200,000-gal. steel tank at the engine terminal now under construction at Binghamton, New York.

The New York Central Railroad has awarded a contract for the extension of its enginehouse at Minoa, New York, and the construction of an office building to cost approximately $50,000.

The Minneapolis, St. Paul & Sault Ste. Marie Railway has awarded a contract for the construction of a four-stall roundhouse and repair shop at Park Falls, Wis.

The Vinita, Bartlesville & Western Railway plans a new line of railway in Oklahoma and is now preparing plans covering locomotive and car repair shops and other structures in connection with the project.

The Missouri, Kansas, Texas Railway plans the construction of a new enginehouse and yards at Eureka, a suburb of Houston, Texas.

The Reading Company plans the construction of a modern car repair shop at Reading, Pa., and the frog shop now at East Penn will be moved to Reading, Pa.

The Chesapeake & Ohio Railway plans the construction of a new enginehouse at Chinnville, Ky.

The Central Railroad of New Jersey plans the construction of a sand-blast house at its Elizabeth shops to be one story high and 30 by 90 ft.

The Union Pacific Railroad coal bin at La Salle, Col., was destroyed by fire on November 10 with a loss estimated at $75,000.

The St. Louis-San Francisco Railway is reported to be planning a terminal improvement program at Birmingham, Ala., to cost approximately $1,000,000.

The Atchison, Topeka & Santa Fe Railway has placed a contract covering a 165 by 175 ft. shop addition and a 90 by 510 ft. addition to the locomotive erection shop at San Bernardino, Calif., both to be reinforced concrete and steel.

Items of Personal Interest

J. S. Ford, road foreman of engines on the Chicago, Burlington & Quincy Railroad, with headquarters at Aurora, Ill., has been promoted to assistant master mechanic of the Galesburg division, with headquarters at Galesburg, Ill.

John P. Morris, formerly general foreman, has been appointed master mechanic of the Illinois division of the Santa Fe, with headquarters at Chicago, Ill., vice **James McDonough** retired. **Edward C. Hanneman** has been appointed to succeed Mr. Morris.

O. C. Branch has been appointed assistant road foreman of engines of the Seaboard Air Line, with headquarters at Hamlet, N. C.

G. H. Warning has been appointed master mechanic of the Saskatchewan division of the Canadian National Railways, with headquarters at Regina, Saskatchewan, succeeding **H. R. Simpson.**

W. P. Hartman has been appointed roundhouse foreman of the Atchison, Topeka & Santa Fe Railway, with headquarters at Albuquerque, New Mexico.

Edward B. LeVan, road foreman of the Northern Pacific Railway, with headquarters at Missoula, Mont., has been transferred to Livingston, Mont.

B. M. Brown, superintendent of motive power of the Southern Pacific Lines, Louisiana division, has been promoted to chief assistant superintendent of motive power of the lines in Texas, succeeding **R. U. Lipscomb.**

C. H. Bradley has been appointed general foreman of the freight car repair department of the new shops of the Southern Railway, with headquarters at Hayne, S. C.

T. L. Hartsock, night foreman of the East Altoona enginehouse of the Pennsylvania Railroad, has been appointed day foreman, succeeding **B. K. Stewart.**

C. F. Parker has been appointed master mechanic of the Kansas City Southern Railway, with headquarters at Heavener, Okla., succeeding **F. A. Prewitt.**

T. W. Lowe, assistant general foreman of the Columbus shops of the Pennsylvania Railroad, has been appointed general foreman, succeeding **R. F. Lace**, deceased.

R. U. Lipscomb has been appointed superintendent of motive power of the Southern Pacific Co., with headquarters at El Paso, Texas. **E. Gordon**, formerly master mechanic of the El Paso & Southwestern Railway, with headquarters at Tucumcari, New Mexico, has been appointed master mechanic of the Southern Pacific Co., with the same headquarters, and **W. G. Reid** has been appointed master mechanic, with headquarters at El Paso, Texas.

John B. Icsman has been appointed master mechanic of the Lehigh & Hudson River Railway, with headquarters at Warwick, New York, succeeding **R. T. Jaynes.**

B. G. Pauley has been appointed master mechanic of the Omaha division of the Chicago, Burlington & Quincy Railroad, with headquarters at Omaha, Nebr.

J. Schneeberger, gang foreman of the Chicago & Alton Railroad has been appointed general erecting shop foreman, with headquarters at Bloomington, Ill., succeeding **A. B. Eriskson.**

E. E. Arnold, general car inspector of the Southern district of the Missouri Pacific Railroad, with headquarters at Little Rock, Ark., has been appointed superintendent of the De Soto shops at De Soto, Mo.

R. L. Ettenger has been appointed assistant to the vice-president, mechanical of the Southern Railway, with headquarters at Washington, D. C.

D. C. Cherry, gang foreman of the Juniata shops of the Pennsylvania Railroad, has been appointed night enginehouse foreman of the East Altoona enginehouse, succeeding **T. L. Hartsock.**

Thomas Paxton, superintendent of motive power of the El Paso & Southwestern Railroad, with headquarters at El Paso, Texas, has retired.

J. R. Wheary has been appointed general foreman of the Norfolk & Western Railway, with headquarters at Crewe, Va., and **C. A. Reinhard** has been appointed general foreman at Williamson, West Va., succeeding **Mr. Wheary**, transferred.

E. A. Koschinske has been appointed superintendent of the Scranton shops of the Delaware, Lackawanna & Western Railroad, succeeding **J. R. Lancaster**, resigned.

Supply Trade Notes

A. J. Manson, manager of the Transportation Division of the New York Office of the Westinghouse Electric & Mfg. Co. for the past four years, has been promoted to manager of the Heavy Traction Division of the Railway Department with headquarters at East Pittsburgh.

A. J. Manson

Mr. Manson, who is considered one of America's foremost authorities on railroad electrification, joined the Westinghouse Company through its engineering apprenticeship course about nineteen years ago, shortly after he graduated as an electrical engineer from the Massachusetts Institute of Technology.

Through his long service with the Westinghouse Company, which included every branch, from construction to sales, Mr. Manson has been connected with nearly all of the important electric transportation problems in the eastern part of the United States. They include helping to build and test the first New Haven locomotive; being assigned to the electrification work of the New York, New Haven & Hartford Railroad in the Spring of 1907 and aiding in the inauguration of electric service; instructing steam engineers in their duties as electric enginemen, and qualifying the early ones for electric service; and being associated with the preliminary test conducted by the Pennsylvania Railroad on Long Island prior to the decision as to the system to be used in the Pennsylvania tunnels entering New York City.

Another accomplishment of Mr. Manson was assisting F. H. Shepard, Director of Heavy Traction of the Westinghouse Company in connection with the Pennsylvania-New York tunnel electrification. This installation included power house, substations and locomotives.

Mr. Manson is well known throughout the electrical and railway world through his book "Railroad Electrification," and his contributions to the railway press. The readers of Railway and Locomotive Engineering will be familiar with his work as he was Associate Editor and conducted the Electrical Department of the publication from 1910 to 1921. Some of the articles that appeared in its pages during the period referred to were the foundation of his book on electrification, which is considered a most authentic publication on this subject.

T. R. Langan, manager of the Transportation Division of the Westinghouse Company at Buffalo, will assume Mr. Manson's duties as manager of the Transportation Division of the New York Office.

O. W. J. Schlacks, formerly President of the Locomotive Lubricator Company, becomes affiliated with the **U. S. Metallic Packing Company**, with the acquisition of the entire business of the Locomotive Lubricator Company by the U. S. Metallic Packing Company.

Mr. Schlacks, after completing his machinist apprenticeship (begun on the Illinois Central Railroad) in the Denver & Rio Grande Railroad, Denver Shops, attended Leland Stanford, Jr., University of Palo Alto, California. He returned to Denver as Assistant Mechanical Engineer on the Denver & Rio Grande Railroad and later Colorado & Southern Railway, successively Mechanical Engineer, General Foreman and Superintendent of Machinery and Rolling Stock, Colorado Midland Railway, Colorado City, Colorado. During part of this time he was President of the Rocky Mountain Railway Club. From September, 1906, to July, 1918, Mr. Schlacks was, successively, Western Sales Agent, General Manager and Vice President and Director of McCord & Company. From 1918 until recently, Mr. Schlacks was President of the Locomotive Lubricator Company. He pioneered force feed lubrication of valves and cylinders of superheater locomotives in this country and eventually realized his ambition in developing an absolutely automatic valve oil delivering device that injects oil into the steam every revolution of the drivers and requires nothing to be turned on or off before or after fill, before or after running summer or winter in any climate. His device proved by test in competition with the three most prominent force feed lubricators of England and Europe as well as three makes in this country, to deliver the most nearly constant quantity of oil through the greatest variations of speeds and temperatures. His latest invention, that of delivering all of the oil into the steam pipe only when the locomotive is working steam and delivering all of the oil into the cylinder only when the locomotive is drifting, is a radical departure that holds great promise for the future of automatic force feed lubrication of the valves and cylinders of superheater locomotives.

G. E. Emmons, vice-president in charge of manufacturing of the **General Electric Company**, Schenectady, New York, who has been with the electrical industry since 1886, has asked to be relieved of the responsibilities of his position and plans to soon move from Schenectady to Pasadena, Calif.

The Chicago Pneumatic Tool Company announce the appointment of **H. E. Byer** as manager of condenser and vacuum pump sales, with headquarters at New York City.

The Canadian Locomotive Company, Toronto, Ontario, has made the following changes in its board of directors: the resignations of **A. Jarvis** and **M. J. Haney** has been accepted: **H. F. Osler** has been appointed a director and **Robert Hobson** has been elected chairman of the board.

Karl Kendig, advertising manager of the **Whitman & Barnes Company**, Akron, Ohio, has been advanced to the position of secretary of the company.

The National Malleable & Steel Castings Company, Cleveland, Ohio, is constructing an annealing plant in Indianapolis, Ind.

Harold Blum has been appointed sales engineer of the **Cleveland Railway Supply Company**. Mr. Blum was formerly connected with the Rail Welding & Bonding Company.

Tom Moore, Royster building, Norfolk, Va., has been appointed railroad sales agent in the southwestern district for the **American Bolt Corporation**, New York.

T. J. Boyd has been appointed factory representative for **Pratt & Whitney Company**, sales of the Niles Bement Pond Company, with headquarters at Philadelphia, Pa.

The Premier Staybolt Company, Pittsburgh, Pa., has opened a Chicago office at 30 North Michigan Blvd., in the Peoples Trust & Bank building. The office is to be in charge of **L. W. Widmeier**, assistant to the presdent.

The stockholders of **Joseph T. Ryerson & Son, Inc.**, has purchased substantial interest in the **Reed Smith Company**, Milwaukee, Wis., under the new plan the officers of the Reed Smith Company are **D. M. Ryerson**, president; **George W. Smith**, vice-president and general manager; **E. L. Hartig**, treasurer; **Carl Gallauer**, secretary.

The Whiting Corporation, Harvey, Ill., has opened a district sales office at 997 Ellicott Square building, Buffalo, New York, to succeed its former agent, George F. Crivel & Co. **W. R. Hans** is to be in charge of the new office. Mr. Hans has been in the service of the Whiting Corporation for many years in the sales and engineering departments.

N. L. Clements, president, and **C. R. Wells**, secretary and treasurer of the **Industrial Works**, Bay City, Mich., have retired. **E. B. Perry**, formerly vice-president and general manager, has been elected president and general manager, succeeding Mr. Clements. **M. D. Platt**, formerly office manager, has been appointed secretary and treasurer, succeeding Mr. Wells.

The Gibb Instrument Company, Bay City, Mich., has changed its name to the **Gibb Welding Machine Company**. No change in organization has been made, the change in name being merely for the purpose of more exactly describing the product. The company is now engaged exclusively in the manufacture of electric welding and heating machines, and no longer makes instruments.

The Kilby Car & Foundry Company, Anniston, Ala., plans to rebuild its foundry which was damaged by fire recently to the extent of $35,000.

C. C. Harchow has been appointed comptroller of the American Steel Foundries, succeeding **Thomas Drever**, resigned to enter other business.

The Air Reduction Sales Company, New York City, is reported to have leased an existing building at Lebanon, Pa., for the establishment of a branch plant for the manufacture of industrial oxygen and kindred products.

Charles H. Bromley has been appointed manager of the lubrication and filtration division of **S. F. Bowser & Co.**, Fort Wayne, Ind.

Walter C. Doering, representative at St. Louis, Mo., of the **Bradford Corporation**, New York City, has been appointed vice-president in charge of the St. Louis office and its business in the southwestern territory.

John L. Barry, Jr., has been appointed representative for the New York district for the **American Crane Company**, headquarters at 30 Church street, New York City.

The Roller Smith Company, New York City, has appointed **Charles R. Speaker**, Evening Star building, Washington, D. C., as sales representative in the District of Columbia, Maryland, Virginia and Carolinas.

Joseph T. Ryerson & Son, Chicago, Ill., plans the construction of two new warehouse spans at the north group of its Chicago plant. The spans are to be 72 by 360 ft. and 100 by 280 ft.

The National Lumber & Creosoting Company, Texarkana, Ark., has appointed **C. B. Mitchell** as district sales manager with headquarters in the Railway Exchange building, Kansas City, Mo.

Henry M. Cleaver has been appointed assistant to the president of the **Niles Bement Pond Company**, with headquarters at New York City. Mr. Cleaver was formerly manager of the Pond works at Plainfield, New Jersey.

J. M. Robb, Monadnock building, Chicago, Ill., has been appointed representative in that territory of the **Economy Railway Supply Company, Ltd.**, Montreal.

Obituary

Charles S. Gawthrop, vice-president of the American Car & Foundry Export Company, died at his home in New York City, on October 31st. after a short illness. Mr. Gawthrop was born in Wilmington, Del., on November 21st. 1868. After graduation from the University of Pensylvania. He entered the employ of the Jackson & Sharp Company, railway car builders, in 1901 when that company was acquired by the American Car and Foundry Company. Mr. Gawthrop became district manager of the Jackson & Sharp plant at Wilmington, Del. which position he held until the formation of the American Car & Foundry Export Company in 1913. He then became director and vice-president of the new corporation and continued in those offices until his death.

E. A. Gregory, district sales manager of the American Brake Shoe & Foundry Co., with headquarters at Houston, Texas, died in a hospital in New York on November 1st. following a severe illness. Mr. Gregory was born in Nashville, Tenn., on March 22nd. 1877, and entered railway service with the Nashville Chattanooga & St. Louis Railway in 1900. In 1903 he was appointed foreman of terminals of the Louisville & Nashville Railroad which position he held until he entered the service of the American Brake Shoe & Foundry Co., on January 15th, 1909. He was appointed district manager at Houston, Texas on March 1st, 1923.

R. T. Jaynes, master mechanic of the Lehigh & Hudson River Railway with headquarters at Warwick, New York died in his office on November 4th, having been in poor health for several months. Mr. Jaynes was born in 1865 and entered railway service as an apprentice in the shop of the Erie Railroad at Susquehanna, Pa. He entered the service of the Lehigh & Hudson River Railway in 1895 as general foreman. In 1907 he was appointed master mechanic which position he held until his death.

Edward H. Utley, vice-president and general manager of the Bessemer & Lake Erie Railroad with headquarters at Pittsburgh, Pa., died at his residence in Pittsburgh on November 8th after a long illness. Mr. Utley became vice-president and general manager on January 15th, 1904, and served continually in that capacity until the time of his death.

New Publications

Books, Bulletins, Catalogues, Etc.

Recent Developments in the Art is the title of folder No. 4631 of the Westinghouse Electric and Manufacturing Company, in which is recorded briefly in forty pages some of the more important developments which that company has contributed to the electric railway industry during the past two years. This booklet is timetable size and was published for use as a guide reference in the Westinghouse Booth at the A. E. R. A. Convention last October.

Part One of this folder is devoted to new developments that were included in the Atlantic City exhibit. Advancements in railway motor design, improvement in control apparatus, modernized renewal parts and other new apparatus are included in this division.

Part Two contains descriptions of more developments not included in the exhibit.

This collection of information under one cover indicates a noteworthy interest of one manufacturer in the industry and its needs. Among the developments may be some solutions to perplexities in equipment which now confront electric railway operators. Copies of this folder will be sent free upon request to any Westinghouse District Office or to the Publicity Department at East Pittsburgh.

Cars and Car Equipment—The Westinghouse Electric and Manufacturing Company have just issued Volume II of their publication—Cars and Car Equipment. The first volume of Cars and Car Equipment was published in 1920 as a reference guide for the selection of car designs for average electric railway applications. This book met with such unanimous approval that it has been found desirable to issue a second edition which includes data and illustrations pertaining to some of the latest and most successful types of cars designed for city, interurban, elevated and parcel dispatch service.

Service performance, general data, weights, dimensions and information on electrical equipment and mechanical equipment, together with photographs and floor plans are included for fifteen different cars. This book is available upon request to either East Pittsburgh or any Westinghouse District Office.

"Die Lokomotive in Kunst, Witz und Karikatur" ("The Locomotive in Art, Humor and Caricature") is the title of a book published in commemoration of the completion of the 10,000th locomotive built by the Hannover Locomotive Works, formerly Georg Egestorff (Hanomag) of Hannover-Linden, Germany. Its contents give an idea as to what extent the illustrative arts, sculpture, and poetry have in a way been influenced by the locomotive. This excellent publication of 130 pages contains not only articles of earnest appreciation and short sketches, but a goodly portion is devoted to the humorous and artistic side of locomotive engineering. It contains many humorous articles and sketches in regard to the iron steed, and the more than 200 illustrations help to make the book a work of exceptional merit. It is to be had from the "Hanomag-Nachrichten-Verlag G. m. b. H.," Hannover-Linden, Germany, at a cost of fifty cents postpaid to the United States.

Superheater Dampers—A new bulletin on Superheater Dampers, Bulletin No. 3, has just been issued by the Superheater Company of New York and Chicago. It describes and illustrates the construction and installation of the damper. Pointers are given against improper installation and regardng the maintenance of dampers. Style R damper for switch engines is also described.

A copy of this bulletin will be sent to anyone mentioning this publication.

Exhaust Steam Injectors.—A booklet giving description and instructions for the Elesco exhaust steam injector has just been issued by The Superheater Company of New York and Chicago. The booklet covers the theory, advantages, operation and troubles of the exhaust steam injectors and also briefly gives instructions for installation and operation. Test results from the New York, Ontario & Western Railway and foreign roads, are given on inserts in the back of the book. The injector is illustrated and types of locomotives to which it has been applied successfully are shown. A copy of this booklet will be sent to any one mentioning this publication.